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ACM NA-2005**Appendix NA - Nonresidential ACM Approval Application**

CALIFORNIA ENERGY RESOURCES

CONSERVATION AND DEVELOPMENT COMMISSION

APPLICATION FOR APPROVAL OF A VENDOR-CERTIFIED ALTERNATIVE CALCULATION METHOD FOR USE IN DEMONSTRATING COMPLIANCE WITH THE NONRESIDENTIAL BUILDING ENERGY EFFICIENCY STANDARDS PER SECTION 141, TITLE 24 OF THE CALIFORNIA CODE OF REGULATIONS

Part I: General Information

1. Organization filing application:

Name: _____ Phone: () _____

Address: _____

2. Name of person responsible for completion of this application:

Name: _____ Phone: () _____

Address: _____

3. Name, Date, and Version of the Alternative Calculation Method (ACM):

Name: _____ Date: _____

Version: _____

4. Has a previous version of this ACM ever been certified?

[] YES [] NO

5. Has this ACM been previously submitted for approval or certification?

[] YES [] NO

6. Has this ACM ever been used to analyze the energy use of a building in California?

[] YES [] NO

7. Has this ACM ever been used to determine compliance with the energy efficiency standards of California?

[] YES [] NO

VENDOR CERTIFICATION OF ALTERNATIVE CALCULATION METHOD

I/We, _____, certify that the alternative calculation method (ACM), herein
name(s) _____

designated _____, version _____, dated _____,
name of alternative calculation method _____ version _____ last saved update _____

occupying _____ bytes of memory, conforms to all of the requirements specified for an exact memory size in bytes

ACM for Commission approval listed in the Nonresidential ACM Approval Manual. I/We specifically certify that this ACM sucessfully conforms to the test criteria for each and every ACM capability test in Chapter 4 of the Alternative Calculation Method (ACM) Approval Manual for the Nonresidential building energy efficiency standards. Moreover, I/we certify that, to the best of my/our knowledge and belief, we have found no instances where this ACM would indicate compliance for a proposed building that the reference computer program using the the reference method would indicate fails to comply with the building energy efficiency standards.

I/We also understand that all required inputs must be available in any approvable ACM but the ACM is not required to model the features described by a given set of inputs. I/We stipulate that this ACM gives the user access to the required inputs and that this ACM automatically warns the user when building inputs use features that the ACM cannot model with sufficient accuracy and automatically fails the proposed building by a margin sufficient to meet the test criteria for any test of that capability.

Signed:

Date:

**ACM Application Test Results for
Required Capabilities Tests**

TEST	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITER	RECPPr	CR3	CR4
A11A09												
A12A09												
A13A09												
A21B13												
A22B13												
A23B06												
A24B16												
A25B03												
A26B13												
A27B16												
B11B13												
B12B13												
B13B13												
B14B06												
B15B16												
B21B12												
B22B12												
B23B12												

DTi = PTi - STi where i is either 'a' for acm or 'r' for reference

CR1 = DTa - (0.85 × DTr - 1) > 0 when DTa ≥ 0

CR3 = LITEa/LITER must be ≥ 0.980 and ≤ 1.020

CR2 = DTa - (1.15 × DTr - 1) > 0 when DTa < 0

CR4 = RECPa/RECPPr must be ≥ 0.980 and ≤ 1.020

**ACM Application Test Results for
Required Capabilities Tests**

TEST	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITER	RFCPr	CR3	CR4
B24B03												
B31D12												
B32D12												
C11A10												
C12A10												
C13A10												
C14A10												
C15A10												
C21B10												
C22C16												
D11D12												
D12D12												
D13D07												
D14D07												
E11D16												
E12D16												
E13D16												
E14D14												

DTi = PTi - STi where i is either 'a' for acm or 'r' for reference

CR1 = DTa - (0.85 × DTr - 1) > 0 when DTa ≥ 0

CR3 = LITEa/LITER must be ≥ 0.980 and ≤ 1.020

CR2 = DTa - (1.15 × DTr - 1) > 0 when DTa < 0

CR4 = RECPa/RECPr must be ≥ 0.980 and ≤ 1.020

**ACM Application Test Results for
Required Capabilities Tests**

TTEST	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITER	RFCPr	CR3	CR4
E15D14												
E16D14												
E21B16												
E22B16												
E23B16												
E24B12												
E25B12												
E26B12												
F11A07												
F12A13												
F13B12												
F14B12												
F15A01												
G11A11												
G12A11												
G13A11												
G14A11												
G15B03												
G16B16												

DTi = PTi - STi where i is either 'a' for acm or 'r' for reference

$$\text{CR1} = \text{DTa} - (0.85 \times \text{DTr} - 1) > 0 \text{ when } \text{DTa} \geq 0$$

$$\text{CR3} = \text{LITEa}/\text{LITER} \text{ must be } \geq 0.980 \text{ and } \leq 1.020$$

$$\text{CR2} = \text{DTa} - (1.15 \times \text{DTr} - 1) > 0 \text{ when } \text{DTa} < 0$$

$$\text{CR4} = \text{RECPa}/\text{RECPr} \text{ must be } \geq 0.980 \text{ and } \leq 1.020$$

**ACM Application Test Results for
Optional Capabilities Tests**

TEST	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITER	RFCPr	CR3	CR4
OC1A09												
O11B13												
O12B13												
O21B13												
O22B13												
O23B13												
O24B13												
O31A12												
O32A12												
O33A12												
O41B13												
O61B12												
O62B12												
O63B12												
O64B12												
O65B12												
O66B12												

$DTi = PTi - STi$ where i is either 'a' for acm or 'r' for reference

$$CR1 = DTa - (0.85 \times DTr - 1) > 0 \text{ when } DTa \geq 0$$

$$CR2 = DTa - (1.15 \times DTr - 1) > 0 \text{ when } DTa < 0$$

$$CR3 = LITEa/LITER \text{ must be } \geq 0.980 \text{ and } \leq 1.020$$

$$CR4 = RECPa/RECPr \text{ must be } \geq 0.980 \text{ and } \leq 1.020$$

**ACM Application Test Results for
Optional Capabilities Tests**

TEST	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITER	RFCPr	CR3	CR4
O71B12												
O81A11												
O82A15												
O91A13												
O92A11												
O93A12												
O94A13												

$DTi = PTi - STi$ where i is either 'a' for acm or 'r' for reference

$$CR1 = DTa - (0.85 \times DTr - 1) > 0 \text{ when } DTa \geq 0$$

$$CR2 = DTa - (1.15 \times DTr - 1) > 0 \text{ when } DTa < 0$$

$$CR3 = LITEa/LITER \text{ must be } \geq 0.980 \text{ and } \leq 1.020$$

$$CR4 = RECPa/RECPr \text{ must be } \geq 0.980 \text{ and } \leq 1.020$$

ACM NB-2005**Appendix NB - Illuminance Categories and Luminaire Power****Illuminance Categories**

Please see Chapter 10 in the IESNA Lighting Handbook, Ninth Edition.

Illuminance Categories and Luminaire Power

Luminaire power shall be taken from the following tables.

Table NB-1 – Fluorescent Circline

Table NB-2 – Compact Fluorescent 2D

Table NB-3 – Compact Fluorescent

Table NB-4 –Long Compact Fluorescent

Table NB-5 – Fluorescent U-Tubes

Table NB-6 – Fluorescent Linear Lamps – Preheat

Table NB-7 – Fluorescent Linear Lamps T5

Table NB-8 – Fluorescent Rapid Start T-8

Table NB-9 – Fluorescent Rapid Start T-12

Table NB-10 – Fluorescent Rapid Start High Output (HO) T8 & T12, 8 ft

Table NB-11 – Fluorescent Instant Start (single pin base "Slimline") T12, 4 ft

Table NB-12 – Fluorescent Instant Start (single pin base "Slimline") T8 & T12, 8 ft.

Table NB-13 – High Intensity Discharge

Table NB-14 – 12 Volt Tungsten Halogen Lamps Including MR16, Bi-pin, AR70, AR111, PAR36

Table NB-1 – Fluorescent Circline

Type	Lamps		Ballasts			System Watts	Comment
	Number	Designation	Number	Designation	Description		
Rapid Start (22 W)	1	FC8T9	1	MAG STAND.	Mag. Stand.	27	8" OD
T5 Program Start (22 W)	1	FC9T5	1	ELECT NO	Electronic Normal Light	28	8" OD
	2	FC9T5	1	ELECT NO	Electronic Normal Light	53	
T5 Program Start (40 W)	1	FC12T5	1	ELECT NO	Electronic Normal Light	41	12" OD
	2	FC12T5	1	ELECT NO	Electronic Normal Light	80	
T5 Rapid Start (55 W)	1	FC12T5HO	1	ELECT NO	Electronic Normal Light	55	12" OD
	2	FC12Tag5HO	1	ELECT NO	Electronic Normal Light	103	
	1	FC12T5HO	1	ELECT DIM	Electronic Dimming	12~59	
	2	FC12T5HO	1	ELECT DIM	Electronic Dimming	24~114	
T5 Rapid Start (40 + 22 W)	1+1	FC12T5/FC9T5	1	ELECT NO	Electronic Normal Light	68	8" & 12" OD

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-2 – Compact Fluorescent 2D

Type	Lamps		Ballasts			System Watts	Comment
	Number	Designation	Number	Designation	Description		
10W, GR10q-4 Four Pin Base	1	CFS10W/GR10q	1	MAG STD	Mag. Stand.	16	3.6" across
	1	CFS10W/GR10q	1	ELECT	Electronic	13	
	2	CFS10W/GR10q	1	ELECT	Electronic	26	
16W, GR10q-4 Four Pin Base	1	CFS16W/GR10q	1	MAG STD	Mag. Stand.	23	5.5" across
	1	CFS16W/GR10q	1	ELECT	Electronic	15	
	2	CFS16W/GR10q	1	ELECT	Electronic	30	
21W, GR10q-4 Four Pin Base	1	CFS21W/GR10q	1	MAG STD	Mag. Stand.	31	5.5" across
	1	CFS21W/GR10q	1	ELECT	Electronic	21	
	2	CFS21W/GR10q	1	ELECT	Electronic	42	
28W, GR10q-4 Four Pin Base	1	CFS28W/GR10q	1	MAG STD	Mag. Stand.	38	8.1" across
	1	CFS28W/GR10q	1	ELECT	Electronic	28	
	2	CFS28W/GR10q	1	ELECT	Electronic	56	
(38W, GR10q-4 Four Pin Base	1	CFS38W/GR10q	1	ELECT	Electronic	37	8.1" across
	2	CFS38W/GR10q	1	ELECT	Electronic	74	

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-3 – Compact Fluorescent

Type	Lamps		Ballasts			System Watts	Comment
	Number	Designation	Number	Designation	Description		
Twin (5 W, G23 Two Pin Base - F5TT Lamp)	1	CFT5W/G23	1	MAG STD	Mag. Stand.	9	4.1" MOL
	2	CFT5W/G23	2	MAG STD	Mag. Stand.	18	
Twin (7 W, G23 Two Pin Base - F7TT Lamp)	1	CFT7W/G23	1	MAG STD	Mag. Stand.	11	5.3" MOL
	2	CFT7W/G23	2	MAG STD	Mag. Stand.	22	
Twin (7 W, 2G7 Four Pin Base - F7TT Lamp)	1	CFT7W/2G7	1	ELECT	Electronic	8	5.3" MOL
	2	CFT7W/2G7	2	ELECT	Electronic	16	
Twin (9 W, G23 Two Pin Base - F9TT Lamp)	1	CFT9W/G23	1	MAG STD	Mag. Stand.	13	6.5" MOL
	2	CFT9W/G23	2	MAG STD	Mag. Stand.	26	
Twin (9 W, 2G7 Four Pin Base - F9TT Lamp)	1	CFT9W/2G7	1	ELECT	Electronic	10	6.5" MOL
	2	CFT9W/2G7	2	ELECT	Electronic	20	
Twin (13 W, GX23 Two Pin Base - F13TT)	1	CFT13W/GX 23	1	MAG STD	Mag. Stand.	17	7.5" MOL
	2	CFT13W/GX 23	2	MAG STD	Mag. Stand.	34	
Twin (13 W, 2GX7 Four Pin Base - F13TT)	1	CFT13W/2G X7	1	ELECT	Electronic	17	7.5" MOL
	2	CFT13W/2G X7	2	ELECT	Electronic	34	
Quad (9 W, G23-2 Two Pin Base - F9DTT Lamp)	1	CFQ9W/G23- 2	1	MAG STD	120 V Mag. Stand.	13	4.4" MOL
	2	CFQ9W/G23- 2	2	MAG STD	120 V Mag. Stand.	26	
Quad (13 W, G24d-1 Two Pin Base - F13DTT Lamp)	1	CFQ13W/G2 4d-1	1	MAG STD	120 V Mag. Stand.	18	6.0" MOL
	2	CFQ13W/G2 4d-1	2	MAG STD	120 V Mag. Stand.	36	
	1	CFQ13W/G2 4d-1	1	MAG STD	277 V Mag. Stand.	16	
	2	CFQ13W/G2 4d-1	2	MAG STD	277 V Mag. Stand.	32	
Quad (13 W, GX23-2 Two Pin Base)	1	CFQ13W/GX 23-2	1	MAG STD	Mag. Stand.	17	4.8" MOL
	2	CFQ13W/GX 23-2	2	MAG STD	Mag. Stand.	34	
Quad (16W GX32d-1 Two Pin Base)	1	CFQ16W/GX 32d-1	1	MAG STD	Mag. Stand.	20	5.5" MOL
	2	CFQ16W/GX 32d-1	2	MAG STD	Mag. Stand.	40	
Quad (18 W, G24d-2 Two Pin Base - F18DTT Lamp)	1	CFQ18W/G2 4d-2	1	MAG STD	120 V Mag. Stand.	25	6.8" MOL
	2	CFQ18W/G2 4d-2	2	MAG STD	120 V Mag. Stand.	50	
	1	CFQ18W/G2 4d-2	1	MAG STD	227 V Mag. Stand.	22	
	2	CFQ18W/G2 4d-2	2	MAG STD	227 V Mag. Stand.	44	
	1	CFQ22W/GX 32d-2	1	MAG STD	Mag. Stand.	27	6.0" MOL
	2	CFQ22W/GX 32d-2	2	MAG STD	Mag. Stand.	54	

Type	Lamps			Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description		
Quad (22W, GX32d Two Pin Base)	2	CFQ22W/GX 32d-2	2	MAG STD	Mag. Stand.	54	
Quad (26 W, G24d-3 Two Pin Base - F26DTT Lamp)	1	CFQ26W/G2 4d-3	1	MAG STD 120	120 V Mag. Stand.	37	7.6" MOL
	2	CFQ26W/G2 4d-3	2	MAG STD 120	120 V Mag. Stand.	74	
	1	CFQ26W/G2 4d-3	1	MAG STD 277	227 V Mag. Stand.	33	
	2	CFQ26W/G2 4d-3	2	MAG STD 277	227 V Mag. Stand.	66	
	1	CFQ26W/G2 4d-3	1	ELECT 277V	277 V Electronic	27	
	2	CFQ26W/G2 4d-3	2	ELECT 277V	277 V Electronic	54	
Quad (28W GX32d Two Pin Base)	1	CFQ28W/GX 32d-3	1	MAG STD	Mag. Stand.	34	6.8" MOL
	2	CFQ28W/GX 32d-3	2	MAG STD	Mag. Stand.	68	
Quad (10 W, G24q-1 Four Pin Base)	1	CFQ10W/G2 4q-1	1	MAG STD 120	120 V Mag. Stand.	16	4.6" MOL
	2	CFQ10W/G2 4q-1	2	MAG STD 120	120 V Mag. Stand.	32	
	1	CFQ10W/G2 4q-1	1	MAG STD 277	227 V Mag. Stand.	13	
	2	CFQ10W/G2 4q-1	2	MAG STD 277	227 V Mag. Stand.	26	
Quad (13 W, G24q-1 Four Pin Base)	1	CFQ13W/G2 4q-1	1	MAG STD 120	120 V Mag. Stand.	18	6.0" MOL
	2	CFQ13W/G2 4q-1	2	MAG STD 120	120 V Mag. Stand.	36	
	1	CFQ13W/G2 4q-1	1	MAG STD 277	227 V Mag. Stand.	16	
	2	CFQ13W/G2 4q-1	2	MAG STD 277	227 V Mag. Stand.	32	
	1	CFQ13W/G2 4q-1	1	ELECT	Electronic	14	
	2	CFQ13W/G2 4q-1	2	ELECT	Electronic	25	
Quad (13 W, GX7 Four Pin Base)	1	CFQ13W/GX Z	1	MAG STD	Mag. Stand.	17	4.8" MOL
	2	CFQ13W/GX Z	2	MAG STD	Mag. Stand.	34	
Quad (18 W, G24q-2 Four Pin Base)	1	CFQ18W/G2 4q-2	1	MAG STD 120	120 V Mag. Stand.	25	6.8" MOL
	2	CFQ18W/G2 4q-2	2	MAG STD 120	120 V Mag. Stand.	50	
	1	CFQ18W/G2 4q-2	1	MAG STD 277	227 V Mag. Stand.	22	
	2	CFQ18W/G2 4q-2	2	MAG STD 277	227 V Mag. Stand.	44	
	1	CFQ18W/G2 4q-2	1	ELECT	Electronic	21	
	2	CFQ18W/G2 4q-2	2	ELECT	Electronic	38	

Type	Lamps			Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description		
<u>Triple (13 W, GX24q-1 Four Pin Base)</u>	1	<u>CFM 13W/GX24q- 1</u>	1	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>18</u>	<u>4.2" MOL</u>
	2	<u>CFM 13W/GX24q- 1</u>	2	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>36</u>	
	1	<u>CFM 13W/GX24q- 1</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>14</u>	
	2	<u>CFM 13W/GX24q- 1</u>	2	<u>ELECT</u>	<u>Electronic</u>	<u>25</u>	
<u>Triple (18W, GX24q-2 Four Pin Base)</u>	1	<u>CFM 18W/GX24q- 2</u>	1	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>25</u>	<u>5.0" MOL</u>
	2	<u>CFM 18W/GX24q- 2</u>	2	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>50</u>	
	1	<u>CFM 18W/GX24q- 2</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>21</u>	
	2	<u>CFM 18W/GX24q- 2</u>	2	<u>ELECT</u>	<u>Electronic</u>	<u>38</u>	
<u>Triple (26W, GX24q-3 Four Pin Base)</u>	1	<u>CFTR 26W/GX24q- 3</u>	1	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>37</u>	<u>4.9 to 5.4" MOL</u>
	2	<u>CFTR 26W/GX24q- 3</u>	2	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>74</u>	
	1	<u>CFTR 26W/GX24q- 3</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>28</u>	
	2	<u>CFTR 26W/GX24q- 3</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>55</u>	
	1	<u>CFTR 26W/GX24q- 3</u>	1	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>8~29</u>	<u>BF .05~1.0</u>
	2	<u>CFTR 26W/GX24q- 3</u>	1	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>12~57</u>	<u>BF .05~1.0</u>
<u>Triple (32 W, GX24q-3 Four Pin Base)</u>	1	<u>CFTR32WGX 24q-3</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>35</u>	
	2	<u>CFTR32WGX 24q-3</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>69</u>	
	1	<u>CFTR32WGX 24q-3</u>	1	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>9~38</u>	<u>BF .05~1.05</u>
	2	<u>CFTR32WGX 24q-3</u>	1	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>20~76</u>	<u>BF .05~1.05</u>
<u>Triple or Quad (42W, GX24q-4 Four Pin Base)</u>	1	<u>CFTR42WGX 24q-4</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>46</u>	
	2	<u>CFTR42WGX 24q-4</u>	1	<u>ELECT</u>	<u>Electronic</u>	<u>94</u>	
	1	<u>CFTR42WGX 24q-4</u>	1	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>10~49</u>	<u>BF .05~1.05</u>

Type	Lamps			Ballasts		<u>System Watts</u>	<u>Comment</u>
	<u>Number</u>	<u>Designation</u>	<u>Number</u>	<u>Designation</u>	<u>Description</u>		
Triple or Quad (42W, GX24q-4 Four Pin Base) cont.	2	CFTR42WGX 1 24q-4		ELECT DIM	Electronic Dimming	20~98	BF .05~1.05
Triple or Quad (57W, GX24q-5 Four Pin Base)	1	CFTR57WGX 1 24q-5		ELECT	Electronic	62	
	1	CFTR57WGX 1 24q-5		ELECT DIM	Electronic Dimming	18~66	BF .05~1.05
Triple or Quad (70W, GX24q-6 Four Pin Base)	1	CFTR70WGX 1 24q-6		ELECT	Electronic	75	
	1	CFTR70WGX 1 24q-6		ELECT DIM	Electronic Dimming	18~80	BF .05~1.00

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-4 -Long Compact Fluorescent

Type	Lamps			Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description		
<u>T5 Twin (18W - F18TT Lamp)</u>	<u>1</u>	<u>FT18W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>23</u>	<u>BF~1.0</u>
	<u>2</u>	<u>FT18W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>46</u>	<u>BF~1.0</u>
	<u>3</u>	<u>FT18W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>69</u>	
	<u>1</u>	<u>FT18W/2G11</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>24</u>	
	<u>2</u>	<u>FT18W/2G11</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>35</u>	
	<u>3</u>	<u>FT18W/2G11</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>52</u>	
	<u>1</u>	<u>FT24W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>32</u>	
	<u>2</u>	<u>FT24W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>66</u>	
	<u>3</u>	<u>FT24W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>98</u>	
<u>T5 Twin (24-27W- F24TT or F27TT Lamp)</u>	<u>1</u>	<u>FT24W/2G11</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>27</u>	<u>BF~1.0</u>
	<u>2</u>	<u>FT24W/2G11</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>52</u>	<u>BF~1.0</u>
	<u>1</u>	<u>FT36W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>51</u>	
	<u>2</u>	<u>FT36W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>66</u>	
	<u>3</u>	<u>FT36W/2G11</u>	<u>2</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>117</u>	
<u>T5 Twin (36-39W - F36TT or F39TT Lamp)</u>	<u>1</u>	<u>FT36W/2G11</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>37</u>	
	<u>2</u>	<u>FT36W/2G11</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>70</u>	
	<u>1</u>	<u>FT36W/2G11</u>	<u>1</u>	<u>ELECTHO</u>	<u>Electronic High Output</u>	<u>46</u>	<u>BF=1.22</u>
	<u>2</u>	<u>FT36W/2G11</u>	<u>1</u>	<u>ELECTHO</u>	<u>Electronic High Output</u>	<u>86</u>	<u>BF=1.20</u>
	<u>1</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>43</u>	
	<u>2</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>86</u>	
	<u>3</u>	<u>FT40W/2G11</u>	<u>2</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>130</u>	
<u>Electronic Ballasts</u>	<u>1</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT NO</u>	<u>Electronic</u>	<u>41</u>	<u>BF~.90</u>
	<u>2</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT NO1</u>	<u>Electronic</u>	<u>72</u>	<u>BF~.88</u>
	<u>2</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT NO2</u>	<u>Electronic</u>	<u>78</u>	<u>BF~.97</u>
	<u>3</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT NO</u>	<u>Electronic</u>	<u>103</u>	<u>BF~.86</u>
	<u>1</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT HO</u>	<u>Electronic High Output</u>	<u>50</u>	<u>BF ~ 1.1</u>
	<u>1</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT DIM1</u>	<u>Electronic Dimming</u>	<u>10-41</u>	<u>BF .05~1.0</u>
	<u>2</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT DIM1</u>	<u>Electronic Dimming</u>	<u>17-80</u>	<u>BF .05~1.0</u>
	<u>1</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT DIM2</u>	<u>Electronic Dimming</u>	<u>11-38</u>	<u>BF .05~.88</u>
	<u>2</u>	<u>FT40W/2G11</u>	<u>1</u>	<u>ELECT DIM2</u>	<u>Electronic Dimming</u>	<u>16-76</u>	<u>BF .05~.88</u>
	<u>1</u>	<u>FT50W/2G11</u>	<u>1</u>	<u>ELECT NO</u>	<u>Electronic Normal Output</u>	<u>54</u>	<u>BF~.98</u>
<u>T5 Twin (50 W - F50TT Lamp)</u>	<u>2</u>	<u>FT50W/2G11</u>	<u>1</u>	<u>ELECT NO</u>	<u>Electronic Normal Output</u>	<u>106</u>	<u>BF~.98</u>
	<u>1</u>	<u>FT50W/2G11</u>	<u>1</u>	<u>ELECT HO</u>	<u>Electronic High Output</u>	<u>61</u>	<u>BF~1.12</u>
	<u>2</u>	<u>FT50W/2G11</u>	<u>1</u>	<u>ELECT HO</u>	<u>Electronic High Output</u>	<u>115</u>	<u>BF~1.10</u>
	<u>1</u>	<u>FT50W/2G11</u>	<u>1</u>	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>51</u>	
	<u>2</u>	<u>FT50W/2G11</u>	<u>1</u>	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>92</u>	
<u>T5 Twin (55 W - F55TT Lamp)</u>	<u>1</u>	<u>FT55W/2G11</u>	<u>1</u>	<u>ELECT NO</u>	<u>Electronic Normal Output</u>	<u>58</u>	<u>BF~.92</u>
	<u>2</u>	<u>FT55W/2G11</u>	<u>1</u>	<u>ELECT NO</u>	<u>Electronic Normal Output</u>	<u>109</u>	<u>BF~.90</u>

<u>Type</u>	<u>Lamps</u>			<u>Ballasts</u>			<u>System Watts</u>	<u>Comment</u>
	<u>Number</u>	<u>Designation</u>	<u>Number</u>	<u>Designation</u>	<u>Description</u>			
	<u>1</u>	<u>FT55W/2G11</u>	<u>1</u>	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>13-59</u>	<u>BF .03~.90</u>	
	<u>2</u>	<u>FT55W/2G11</u>	<u>1</u>	<u>ELECT DIM</u>	<u>Electronic Dimming</u>	<u>24-114</u>	<u>BF .03~.90</u>	
<u>T5 Twin (80 W – F80TT Lamp)</u>	<u>1</u>	<u>FT80W/2G11</u>	<u>1</u>	<u>ELECT NO</u>	<u>Electronic</u>	<u>91</u>	<u>BF~1.00</u>	

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-5 – Fluorescent U-Tubes

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designatio n		
2 ft. Fluorescent U-Tube T8 (32W - FBO31T8 or F32T8/U/6 Lamp)	1	FB31T8/F32T8U	0.5	MAG.	Mag. Energy Efficient 35	Tandem wired
	1	FB31T8/F32T8U	1	MAG.	Mag. Energy Efficient 36	
	2	FB31T8/F32T8U	1	MAG.	Mag. Energy Efficient 69	
	3	FB31T8/F32T8U	1.5	MAG.	Mag. Energy Efficient 104	Tandem wired
	3	FB31T8/F32T8U	2	MAG.	Mag. Energy Efficient 105	
	1	FB31T8/F32T8U	1	ELECT NO	Electronic Normal Output	39
	2	FB31T8/F32T8U	1	ELECT NO	Electronic Normal Output	62
	3	FB31T8/F32T8U	1	ELECT NO	Electronic Normal Output	92
	4	FB31T8/F32T8U	1	ELECT NO	Electronic Normal Output	
	1	FB31T8/F32T8U	1	ELECT DIM	Electronic Dimming 9~33	BF .05~.88
	2	FB31T8/F32T8U	1	ELECT DIM	Electronic Dimming 14~64	BF .05~.88
	3	FB31T8/F32T8U	1	ELECT DIM	Electronic Dimming 18~93	BF .05~.88
	4	FB31T8/F32T8U	1	ELECT DIM	Electronic Dimming 25~116	BF .05~.88
2 ft. Fluorescent U-Tube T12 ("Energy Saving" 34W)	1	FB40T12/ES	0.5	MAG.	Mag. Energy Efficient 36	Tandem wired
	1	FB40T12/ES	1	MAG.	Mag. Energy Efficient 43	
	2	FB40T12/ES	1	MAG.	Mag. Energy Efficient 72	
	3	FB40T12/ES	1	MAG.	Mag. Energy Efficient 105	
	3	FB40T12/ES	1.5	MAG.	Mag. Energy Efficient 108	Tandem wired
	3	FB40T12/ES	2	MAG.	Mag. Energy Efficient 115	
	1	FB40T12/ES	0.5	ELECT	Electronic 30	Tandem wired
	1	FB40T12/ES	1	ELECT	Electronic 31	
	2	FB40T12/ES	1	ELECT	Electronic 59	
	3	FB40T12/ES	1	ELECT	Electronic 90	
	3	FB40T12/ES	1.5	ELECT	Electronic 88	Tandem wired
	3	FB40T12/ES	2	ELECT	Electronic 90	

RO = ballast factor 70 to 85%

NO = ballast factor 85 to 100%

HO = ballast factor >100%

Table NB-6 – Fluorescent Linear Lamps – Preheat

Type	Lamps		Ballasts			System Watts	Comment
	Nmbr	Designation	Nmbr	Designation	Description		
Fluorescent Preheat T5 (8W)	1	F8T5	1	MAG STD	Mag. Stand.	12	12" MOL
Fluorescent Preheat T8 (15W)	1	F15T8	1	MAG STD	Mag. Stand.	19	18" MOL
Fluorescent Preheat T12 (15W)	1	F15T12	1	MAG STD	Mag. Stand.	19	18" MOL
Fluorescent Preheat T12 (20W)	1	F20T12	1	MAG STD	Mag. Stand.	25	24" MOL
	2	F20T12	1	MAG STD	Mag. Stand.	50	24" MOL
Fluorescent Preheat T8 (30W)	1	F30T8	1	MAG STD	Mag. Stand.	46	30" MOL
	2	F30T8	1	MAG STD	Mag. Stand.	79	30" MOL

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-7 – Fluorescent Linear Lamps T5

Type	Lamps		Ballasts			System Watts	Comment
	Number	Designation	Number	Designation	Description		
~23" Fluorescent Program Start T5 (14W)	1	F14T5	1	ELECT	Elect. Program Start BF=1	18	
	2	F14T5	1	ELECT	Elect. Program Start BF=1	34	
~34.5" Fluorescent Program Start T5 (21W)	1	F21T5	1	ELECT	Elect. Program Start BF=1	27	
	2	F21T5	1	ELECT	Elect. Program Start BF=1	50	
~46" Fluorescent Program Start T5 (28W)	1	F28T5	1	ELECT	Elect. Program Start BF=1	30	
	2	F28T5	1	ELECT	Elect. Program Start BF=1	60	
~58.5" Fluorescent Program Start T5 (35W)	1	F35T5	1	ELECT	Elect. Program Start BF=1	40	
	2	F35T5	1	ELECT	Elect. Program Start BF=1	78	
~23" Fluorescent Program Start T5 High Output (24W)	1	F24T5HO	1	ELECT	Elect. Program Start BF=1	27	
	2	F24T5HO	1	ELECT	Elect. Program Start BF=1	52	
~34.5" Fluorescent Program Start T5 High Output(39W)	1	F39T5	1	ELECT	Elect. Program Start BF=1	43	
	2	F39T5	1	ELECT	Elect. Program Start BF=1	85	
~46" Fluorescent Program Start T5 High Output (54W)	1	F54T5	1	ELECT	Elect. Program Start BF=1	62	
	2	F54T5	1	ELECT	Elect. Program Start BF=1	117	
	1	F54T5	1	ELECT	Elect. Dimming DIM	12-63	
	2	F54T5	1	ELECT	Elect. Dimming DIM	24-125	
~57.5" Fluorescent Program Start T5 High Output (80W)	1	F80T5	1	ELECT	Elect. Program Start BF=1	89	

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-8 – Fluorescent Rapid Start T-8

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
2 foot Fluorescent Rapid Start T8 (17W)	1	F17T8	1	MAG.	Mag. Energy Efficient	24
	2	F17T8	1	MAG.	Mag. Energy Efficient	45
Electronic Ballasts	1	F17T8	1	ELECT NO	Electronic Normal Output	22
	2	F17T8	1	ELECT NO	Electronic Normal Output	33
	3	F17T8	1	ELECT NO	Electronic Normal Output	53
	3	F17T8	2	ELECT NO	Electronic Normal Output	55
	4	F17T8	1	ELECT NO	Electronic Normal Output	63
2 foot Fluorescent Rapid Start T8 (17W)	1	F17T8	1	ELECT DIM	Electronic Dimming	8~20
	2	F17T8	1	ELECT DIM	Electronic Dimming	10~37
	3	F17T8	1	ELECT DIM	Electronic Dimming	12~56
	4	F17T8	1	ELECT DIM	Electronic Dimming	18~69
3 foot Fluorescent Rapid Start T8 (25W)	1	F25T8	1	MAG.	Mag. Energy Efficient	33
	2	F25T8	1	MAG.	Mag. Energy Efficient	65
Electronic Ballasts	1	F25T8	1	ELECT NO	Electronic Normal Output	27
	2	F25T8	1	ELECT NO	Electronic Normal Output	48
	3	F25T8	1	ELECT NO	Electronic Normal Output	68
	4	F25T8	1	ELECT NO	Electronic Normal Output	89
	1	F25T8	1	ELECT RO	Electronic Reduced Output	24
	2	F25T8	1	ELECT RO	Electronic Reduced Output	41
	3	F25T8	1	ELECT RO	Electronic Reduced Output	59
	4	F25T8	1	ELECT RO	Electronic Reduced Output	76
	1	F25T8	1	ELECT HO	Electronic High Output	29
	2	F25T8	1	ELECT HO	Electronic High Output	51
	3	F25T8	1	ELECT HO	Electronic High Output	74
	1	F25T8	1	ELECT DIM	Electronic Dimming	8~25
						BF .05~.94

Type	Lamps		Ballasts		System Watts	Comment	
	Number	Designation	Number	Designation	Description		
<u>Electronic Ballasts</u> <u>cont.</u>	2	F25T8	1	ELECT DIM	Electronic Dimming	13~49	BF .05~.94
	3	F25T8	1	ELECT DIM	Electronic Dimming	16~76	BF .05~.94
	4	F25T8	1	ELECT DIM	Electronic Dimming	22~96	BF .05~.88
	1	F25T12ES	1	ELECT NO	Electronic Normal Output	27	
<u>4 foot Fluorescent Rapid Start T12 for T-8 ballasts ("Energy Saving" 25W)</u>	2	F25T12ES	1	ELECT NO	Electronic Normal Output	52	
	3	F25T12ES	1	ELECT NO	Electronic Normal Output	77	
	4	F25T12ES	1	ELECT NO	Electronic Normal Output	95	
	1	F32T8/30ES	1	ELECT NO	Electronic Normal Output	29	
<u>4 foot Fluorescent Instant Start T8 ("Energy Saving" 30W)</u>	2	F32T8/30ES	1	ELECT NO	Electronic Normal Output	54	
	3	F32T8/30ES	1	ELECT NO	Electronic Normal Output	79	
	4	F32T8/30ES	1	ELECT NO	Electronic Normal Output	104	
	1	F32T8/30ES	1	ELECT RO	Electronic Reduced Output	27	
	2	F32T8/30ES	1	ELECT RO	Electronic Reduced Output	48	
	3	F32T8/30ES	1	ELECT RO	Electronic Reduced Output	70	
	4	F32T8/30ES	1	ELECT RO	Electronic Reduced Output	91	
	1	F32T8/30ES	1	ELECT NO	EE Normal Output	33	
	2	F32T8/30ES	1	ELECT NO	Energy efficiency Normal Output	52	
	3	F32T8/30ES	1	ELECT NO	Energy efficiency Normal Output	77	
	4	F32T8/30ES	1	ELECT NO	Energy efficiency Normal Output	101	
	1	F32T8/30ES	1	ELECT RO	EE Reduced Output	28	
<u>4 foot Fluorescent Rapid Start T8 (32W)</u>	2	F32T8/30ES	1	ELECT RO	EE Reduced Output	45	
	3	F32T8/30ES	1	ELECT RO	EE Reduced Output	66	
	4	F32T8/30ES	1	ELECT RO	EE Reduced Output	88	
	1	F32T8	0.5	MAG.	Mag. Energy Efficient	35	Tandem wired
	1	F32T8	1	MAG.	Mag. Energy Efficient	39	
	2	F32T8	1	MAG.	Mag. Energy Efficient	70	

Type	Lamps		Ballasts		System Watts	Comment	
	Number	Designation	Number	Designation	Description		
<u>4 foot Fluorescent Rapid Start T8 (32W) cont.</u>	3	F32T8	1.5	MAG.	Mag. Energy Efficient	105	Tandem wired
	3	F32T8	2	MAG.	Mag. Energy Efficient	109	
	4	F32T8	2	MAG.	Mag. Energy Efficient	140	(2) two-lamp ballasts
<u>4 foot Fluorescent Rapid Start T8 (32W)</u>	1	F32T8	1	ELECT NO	Electronic Normal Output	32	
	2	F32T8	1	ELECT NO	Electronic Normal Output	62	
	3	F32T8	1	ELECT NO	Electronic Normal Output	93	
	4	F32T8	1	ELECT NO	Electronic Normal Output	114	
	1	F32T8	1	EE NO	EE Normal Output	35	
	2	F32T8	1	EE NO	EE Normal Output	55	
	3	F32T8	1	EE NO	EE Normal Output	82	
	4	F32T8	1	EE NO	EE Normal Output	107	
	1	F32T8	1	ELECT RO	Electronic Reduced Output	29	
	2	F32T8	1	ELECT RO	Electronic Reduced Output	51	
	3	F32T8	1	ELECT RO	Electronic Reduced Output	76	
	4	F32T8	1	ELECT RO	Electronic Reduced Output	98	
	2	F32T8	1	ELECT HO	Electronic High Output	77	BF~1.13
	3	F32T8	1	ELECT HO	Electronic High Output	112	BF~1.18
	1	F32T8	1	EE RO	EE Reduced Output	30	
	2	F32T8	1	EE RO	EE Reduced Output	48	
	3	F32T8	1	EE RO	EE Reduced Output	73	
	4	F32T8	1	EE RO	EE Reduced Output	96	
<u>2 foot Fluorescent Rapid Start T8 (18W)</u>	2	F32T8	1	ELECT TL	Electronic Two Level (50 & 100%)	65	
	1	F32T8	1	ELECT DIM1	Electronic Dimming	9~35	BF .05~1.0
	2	F32T8	1	ELECT DIM1	Electronic Dimming	15~68	BF .05~1.0
	3	F32T8	1	ELECT DIM1	Electronic Dimming	20~102	BF .05~1.0
	1	F32T8	1	ELECT DIM2	Electronic Dimming	9~33	BF .05~.88
	2	F32T8	1	ELECT DIM2	Electronic Dimming	14~64	BF .05~.88
	3	F32T8	1	ELECT DIM2	Electronic Dimming	18~93	BF .05~.88
	4	F32T8	1	ELECT DIM2	Electronic Dimming	25~116	BF .05~.88

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
<u>5 foot Fluorescent</u> <u>Rapid Start T8 (40W)</u>	1	F40T8	1	MAG.	<u>Mag. Energy Efficient</u>	50
	2	F40T8	1	MAG.	<u>Mag. Energy Efficient</u>	92
	1	F40T8	1	ELECT	<u>Electronic</u>	46
	2	F40T8	1	ELECT	<u>Electronic</u>	79
	3	F40T8	1	ELECT	<u>Electronic</u>	112
<u>3 foot Fluorescent</u> <u>Rapid Start T12</u> <u>("Energy-Saving" 25W)</u>	1	F30T12/ES	1	MAG STD	<u>Mag. Stand.</u>	42
	2	F30T12/ES	1	MAG STD	<u>Mag. Stand.</u>	74
	3	F30T12/ES	1.5	MAG STD	<u>Mag. Stand.</u>	111
	3	F30T12/ES	2	MAG STD	<u>Mag. Stand.</u>	116
	2	F30T12/ES	1	MAG.	<u>Mag. Energy Efficient</u>	66
	1	F30T12/ES	1	ELECT	<u>Electronic</u>	26
	2	F30T12/ES	1	ELECT	<u>Electronic</u>	53
	1	F30T12	1	MAG STD	<u>Mag. Stand.</u>	46
	2	F30T12	1	MAG STD	<u>Mag. Stand.</u>	79
	3	F30T12	1.5	MAG STD	<u>Mag. Stand.</u>	118
<u>3 foot Fluorescent</u> <u>Rapid Start T12</u> <u>("Stand." 30W)</u>	3	F30T12	2	MAG STD	<u>Mag. Stand.</u>	125
	2	F30T12	1	MAG.	<u>Mag. Energy Efficient</u>	73
	1	F30T12	1	ELECT	<u>Electronic</u>	30
	2	F30T12	1	ELECT	<u>Electronic</u>	60
	1	F40T12/ES Plus	0.5	MAG.	<u>Mag. Energy Efficient</u>	34
	1	F40T12/ES Plus	1	MAG.	<u>Mag. Energy Efficient</u>	41
	2	F40T12/ES Plus	1	MAG.	<u>Mag. Energy Efficient</u>	68
	3	F40T12/ES Plus	1	MAG.	<u>Mag. Energy Efficient</u>	99
	3	F40T12/ES Plus	1.5	MAG.	<u>Mag. Energy Efficient</u>	102
	3	F40T12/ES Plus	2	MAG.	<u>Mag. Energy Efficient</u>	109
<u>4 foot Fluorescent</u> <u>Rapid Start T12</u> <u>("Energy-Saving Plus"32W)</u>	4	F40T12/ES Plus	2	MAG.	<u>Mag. Energy Efficient</u>	136
	(2) Two-lamp ballasts					
RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%						

Table NB-9 – Fluorescent Rapid Start T-12

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
4 foot Fluorescent Rapid Start T12 ("Energy-Saving"34W)	1	F40T12/ES	0.5	MAG STD**	Mag. Stand.	42
	1	F40T12/ES	1	MAG STD**	Mag. Stand.	48
	2	F40T12/ES	1	MAG STD**	Mag. Stand.	82
	3	F40T12/ES	1.5	MAG STD**	Mag. Stand.	122
	3	F40T12/ES	2	MAG STD**	Mag. Stand.	130
	4	F40T12/ES	2	MAG STD**	Mag. Stand.	164
						(2) Two-lamp ballasts
	1	F40T12/ES	0.5	MAG.	Mag. Energy Efficient	36
	1	F40T12/ES	1	MAG.	Mag. Energy Efficient	43
	2	F40T12/ES	1	MAG.	Mag. Energy Efficient	72
	3	F40T12/ES	1	MAG.	Mag. Energy Efficient	105
	3	F40T12/ES	1.5	MAG.	Mag. Energy Efficient	108
	3	F40T12/ES	2	MAG.	Mag. Energy Efficient	112
	4	F40T12/ES	2	MAG.	Mag. Energy Efficient	144
						(2) Two-lamp ballasts
	2	F40T12/ES	1	MAG HC	Mag. Heater Cutout	58
	3	F40T12/ES	1.5	MAG HC	Mag. Heater Cutout	87
	4	F40T12/ES	2	MAG HC	Mag. Heater Cutout	116
						(2) Two-lamp ballasts
	2	F40T12/ES	1	MAG HC FO	Mag. Heater Cutout Full Light	66
	3	F40T12/ES	1.5	MAG HC FO	Mag. Heater Cutout Full Light	99
	4	F40T12/ES	2	MAG HC FO	Mag. Heater Cutout Full Light	132
						(2) Two-lamp ballasts
	1	F40T12/ES	0.5	ELECT	Electronic	30
	1	F40T12/ES	1	ELECT	Electronic	31
	2	F40T12/ES	1	ELECT	Electronic	62
	3	F40T12/ES	1	ELECT	Electronic	90
	3	F40T12/ES	1.5	ELECT	Electronic	93
	3	F40T12/ES	2	ELECT	Electronic	93
	4	F40T12/ES	1	ELECT	Electronic	121
	4	F40T12/ES	2	ELECT	Electronic	124
						(2) Two-lamp ballasts

Type	Lamps		Ballasts		System Watts	Comment	
	Number	Designation	Number	Designation	Description		
<u>4 foot Fluorescent Rapid Start T12 ("Energy-Saving"34W) cont.</u>	<u>2</u>	<u>F40T12/ES</u>	<u>1</u>	<u>ELECT AO</u>	<u>Elec. Adjustable Output (to 15%)</u>	<u>60</u>	
	<u>3</u>	<u>F40T12/ES</u>	<u>1.5</u>	<u>ELECT AO</u>	<u>Elec. Adjustable Output (to 15%)</u>	<u>90</u>	<u>Tandem wired</u>
	<u>4</u>	<u>F40T12/ES</u>	<u>2</u>	<u>ELECT AO</u>	<u>Elec. Adjustable Output (to 15%)</u>	<u>120</u>	<u>(2) Two-lamp ballasts</u>
<u>4 foot Fluorescent Rapid Start Stand. (40W)</u>	<u>1</u>	<u>F40T12</u>	<u>0.5</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>44</u>	<u>Tandem wired</u>
	<u>1</u>	<u>F40T12</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>46</u>	
	<u>2</u>	<u>F40T12</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>88</u>	
	<u>3</u>	<u>F40T12</u>	<u>1</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>127</u>	
	<u>3</u>	<u>F40T12</u>	<u>1.5</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>132</u>	<u>Tandem wired</u>
	<u>3</u>	<u>F40T12</u>	<u>2</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>134</u>	
	<u>4</u>	<u>F40T12</u>	<u>2</u>	<u>MAG.</u>	<u>Mag. Energy Efficient</u>	<u>176</u>	<u>(2) Two-lamp ballasts</u>
	<u>2</u>	<u>F40T12</u>	<u>1</u>	<u>MAG HC</u>	<u>Mag. Heater Cutout</u>	<u>71</u>	
	<u>3</u>	<u>F40T12</u>	<u>1.5</u>	<u>MAG HC</u>	<u>Mag. Heater Cutout</u>	<u>107</u>	<u>Tandem wired</u>
	<u>4</u>	<u>F40T12</u>	<u>2</u>	<u>MAG HC</u>	<u>Mag. Heater Cutout</u>	<u>142</u>	<u>(2) Two-lamp ballasts</u>
	<u>2</u>	<u>°F40T12</u>	<u>1</u>	<u>MAG °F FO</u>	<u>Mag. Heater Cutout Full Light</u>	<u>80</u>	
<u>4 foot Fluorescent Rapid Start Stand. (40W) cont.</u>	<u>3</u>	<u>°F40T12</u>	<u>1.5</u>	<u>MAG °F FO</u>	<u>Mag. Heater Cutout Full Light</u>	<u>120</u>	<u>Tandem wired</u>
	<u>4</u>	<u>°F40T12</u>	<u>2</u>	<u>MAG °F FO</u>	<u>Mag. Heater Cutout Full Light</u>	<u>160</u>	<u>(2) Two-lamp ballasts</u>
	<u>1</u>	<u>°F40T12</u>	<u>0.5</u>	<u>ELECT</u>	<u>Electronic</u>	<u>36</u>	<u>Tandem wired</u>
	<u>1</u>	<u>°F40T12</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>37</u>	
	<u>2</u>	<u>°F40T12</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>72</u>	
	<u>3</u>	<u>°F40T12</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>107</u>	
	<u>3</u>	<u>°F40T12</u>	<u>1.5</u>	<u>ELECT</u>	<u>Electronic</u>	<u>108</u>	<u>Tandem wired</u>
	<u>3</u>	<u>°F40T12</u>	<u>2</u>	<u>ELECT</u>	<u>Electronic</u>	<u>109</u>	
	<u>4</u>	<u>°F40T12</u>	<u>1</u>	<u>ELECT</u>	<u>Electronic</u>	<u>135</u>	
	<u>4</u>	<u>°F40T12</u>	<u>2</u>	<u>ELECT</u>	<u>Electronic</u>	<u>144</u>	<u>(2) Two-lamp ballasts</u>
	<u>2</u>	<u>°F40T12</u>	<u>1</u>	<u>ELECT RO</u>	<u>Electronic Reduce Output (75%)</u>	<u>61</u>	
	<u>3</u>	<u>°F40T12</u>	<u>1</u>	<u>ELECT RO</u>	<u>Electronic Reduce Output (75%)</u>	<u>90</u>	
	<u>3</u>	<u>°F40T12</u>	<u>1.5</u>	<u>ELECT RO</u>	<u>Electronic Reduce Output (75%)</u>	<u>92</u>	<u>Tandem wired</u>

Type	Lamps		Ballasts		System <u>Watts</u>	Comment	
	Number	Designation	Number	Designation	Description		
4 foot Fluorescent Rapid Start Stand. (40W) cont.	4	°F40T12	2	ELECT RO	Electronic Reduce Output (75%)	122	(2) Two-lamp ballasts
	2	°F40T12	1	ELECT TL	Elec. Two Level (50 & 100%)	69	
	3	°F40T12	1.5	ELECT TL	Elec. Two Level (50 & 100%)	104	Tandem wired
	4	°F40T12	2	ELECT TL	Elec. Two Level (50 & 100%)	138	(2) Two-lamp ballasts
	2	°F40T12	1	ELECT AO	Elec. Adjustable Output (to 15%)	73	
	3	°F40T12	1.5	ELECT AO	Elec. Adjustable Output (to 15%)	110	Tandem wired
	4	°F40T12	2	ELECT AO	Elec. Adjustable Output (to 15%)	146	(2) Two-lamp ballasts
	2	°F40T12	1	ELECT DIM	Electronic Dimming (to 1%)	83	
	3	°F40T12	1.5	ELECT DIM	Electronic Dimming (to 1%)	125	Tandem wired
	4	°F40T12	2	ELECT DIM	Electronic Dimming (to 1%)	166	(2) Two-lamp ballasts

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-10 – Fluorescent Rapid Start High Output (HO) T8 & T12, 8 ft

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
8 foot Fluorescent Rapid Start T8 High Output (86W)	1	F96T8/HO	1	ELECT	Electronic	<u>88</u>
	2	F96T8/HO	1	ELECT	Electronic	<u>160</u>
8 foot Fluorescent Rapid Start T12 High Output ("Energy- Saving" 95W)	1	F96T12/HO/ES	1	MAG STD	Mag. Stand.	<u>125</u>
	2	F96T12/HO/ES	1	MAG STD**	Mag. Stand.	<u>227</u>
	2	F96T12/HO/ES	1	MAG.	Mag. Energy Efficient	<u>208</u>
	2	F96T12/HO/ES	1	ELECT	Electronic	<u>170</u>
8 foot Fluorescent Rapid Start T12 High Output ("Stand." 110W)	1	F96T12/HO	1	MAG STD	Mag. Stand.	<u>140</u>
	2	F96T12/HO	1	MAG STD**	Mag. Stand.	<u>252</u>
	2	F96T12/HO	1	MAG.	Mag. Energy Efficient	<u>237</u>
	1	F96T12/HO	1	ELECT	Electronic	<u>119</u>
	2	F96T12/HO	1	ELECT	Electronic	<u>205</u>
8 foot Fluorescent Rapid Start T12 Very High Output ("Energy- Saving" 195W)	1	F96T12/VHO/ES	1	MAG STD	Mag. Stand.	<u>200</u>
	2	F96T12/VHO/ES	1	MAG STD	Mag. Stand.	<u>325</u>
8 foot Fluorescent Rapid Start T12 Very High Output ("Stand." 215W)	1	Stand.96T12/VHO	1	MAG STAND.	Mag. Stand.	<u>230</u>
	2	Stand.96T12/VHO	1	MAG STAND.	Mag. Stand.	<u>440</u>

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-11 – Fluorescent Instant Start (single pin base "Slimline") T12, 4 ft

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
4 foot Fluorescent Slimline Energy- Saving T12 (32W)	1	Stand.48T12/ES	1	MAG STAND.	Mag. Stand.	<u>51</u>
	2	Stand.48T12/ES	1	MAG STAND.	Mag. Stand.	<u>82</u>
4 foot Fluorescent Slimline Stand. Stand. (39W)	1	Stand.48T12	1	MAG Stand.	Mag. Stand.	<u>59</u>
	2	Stand.48T12	1	MAG Stand.	Mag. Stand.	<u>98</u>

RO = ballast factor 70 to 85% NO = ballast factor 85 to 100% HO = ballast factor >100%

Table NB-12 – Fluorescent Instant Start (single pin base "Slimline") T8 & T12, 8 ft.

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
8 foot Fluorescent T8 Slimline (59W)	1	F96T8	1	MAG.	Mag. Stand.	58
	2	F96T8	1	MAG.	Mag. Stand.	120
	2	F96T8	1	ELECT NO	Electronic Normal Output	110
	1	F96T8	1	ELECT HO	Electronic High Output	72 BF~1.10
	2	F96T8	1	ELECT HO1	Electronic High Output	140 BF~1.10
	2	F96T8	1	ELECT HO2	Electronic High Output	151 BF~1.20
8 foot Fluorescent T12 Slimline ("Energy-Saving" 60W)	1	F96T12/ES	1	MAG STD	Mag. Stand.	74
	2	F96T12/ES	1	MAG STD**	Mag. Stand.	131
	2	F96T12/ES	1	MAG.	Mag. Energy Efficient	112
	1	F96T12/ES	1	ELECT	Electronic	70
	2	F96T12/ES	1	ELECT	Electronic	107
8 foot Fluorescent T12 Slimline ("Stand." 75W)	1	F96T12	1	MAG STD	Mag. Stand.	92
	2	F96T12	1	MAG STD**	Mag. Stand.	158
	2	F96T12	1	MAG.	Mag. Energy Efficient	144
	1	F96T12	1	ELECT	Electronic	85
	2	F96T12	1	ELECT	Electronic	132

RO = ballast factor 70 to 85%

NO = ballast factor 85 to 100%

HO = ballast factor >100%

Table NB-13 – High Intensity Discharge

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
Mercury Vapor	1	H40	1	MAG STD	Mag. Stand.	51
	1	H50	1	MAG STD	Mag. Stand.	63
	1	H75	1	MAG STD	Mag. Stand.	88
	1	H100	1	MAG STD	Mag. Stand.	119
	1	H175	1	MAG STD	Mag. Stand.	197
	1	H250	1	MAG STD	Mag. Stand.	285
	1	H400	1	MAG STD	Mag. Stand.	450
	1	H1000	1	MAG STD	Mag. Stand.	1080
Metal Halide	1	M35/39	1	MAG STD	Mag. Stand.	48
	1	M35/39	1	ELECT	Electronic	44
	1	M50	1	MAG STD	Mag. Stand.	68
	1	M50	1	ELECT	Electronic	58
	1	M70	1	MAG STD	Mag. Stand.	92
	1	M70	1	ELECT	Electronic	86
	1	M100	1	MAG STD	Mag. Stand.	122
	1	M100	1	ELECT	Electronic	110
	1	M125	1	MAG STD	Mag. Stand.	150
	1	M150	1	MAG STD	Mag. Stand.	186
	1	M150	1	ELECT	Electronic	168
	1	M175	1	MAG STD	Mag. Stand.	205
	1	M200	1	MAG STD	Mag. Stand.	232
	1	M225	1	MAG STD	Mag. Stand.	258
	1	M250	1	MAG STD	Mag. Stand.	295
	1	M320	1	MAG STD	Mag. Stand.	365
	1	M320	1	MAG LR	277v Linear Reactor	345
	1	M360	1	MAG STD	Mag. Stand.	422
	1	M360	1	MAG LR	277v Linear Reactor	388
High Pressure Sodium	1	M400	1	MAG STD	Mag. Stand.	461
	1	M400	1	MAG LR	277v Linear Reactor	426
	1	M450	1	MAG STD	Mag. Stand.	502
	1	M450	1	MAG LR	277v Linear Reactor	478
	1	M750	1	MAG STD	Mag. Stand.	820
	1	M900	1	MAG STD	Mag. Stand.	990
	1	M1000	1	MAG STD	Mag. Stand.	1080
	1	M1500	1	MAG STD	Mag. Stand.	1650
	1	M1650	1	MAG STD	Mag. Stand.	1810

Type	Lamps		Ballasts			System Watts	Comment
	Number	Designation	Number	Designation	Description		
<u>High Pressure Sodium cont.</u>	1	<u>S400</u>	1	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>469</u>	
	1	<u>S1000</u>	1	<u>MAG STD</u>	<u>Mag. Stand.</u>	<u>1090</u>	
<u>Low Pressure Sodium</u>	1	<u>LPS18</u>	1	<u>MAG STAND.</u>	<u>Mag. Stand.</u>	<u>30</u>	
	1	<u>LPS35</u>	1	<u>MAG STAND.</u>	<u>Mag. Stand.</u>	<u>60</u>	
	1	<u>LPS55</u>	1	<u>MAG STAND.</u>	<u>Mag. Stand.</u>	<u>80</u>	
	1	<u>LPS90</u>	1	<u>MAG STAND.</u>	<u>Mag. Stand.</u>	<u>125</u>	
	1	<u>LPS135</u>	1	<u>MAG STAND.</u>	<u>Mag. Stand.</u>	<u>178</u>	
	1	<u>LPS180</u>	1	<u>MAG STAND.</u>	<u>Mag. Stand.</u>	<u>220</u>	

RO = ballast factor 70 to 85%

NO = ballast factor 85 to 100%

HO = ballast factor >100%

Table NB-14 – 12 Volt Tungsten Halogen Lamps Including MR16, Bi-pin, AR70, AR111, PAR36

Type	Lamps		Ballasts		System Watts	Comment
	Number	Designation	Number	Designation	Description	
	1	20 watt lamp	1	ELECT	Electronic Power Supply	23
	1	25 watt lamp	1	ELECT	Electronic Power Supply	28
	1	35 watt lamp	1	ELECT	Electronic Power Supply	38
	1	37 watt lamp	1	ELECT	Electronic Power Supply	41
	1	42 watt lamp	1	ELECT	Electronic Power Supply	45
	1	50 watt lamp	1	ELECT	Electronic Power Supply	54
	1	65 watt lamp	1	ELECT	Electronic Power Supply	69
	1	71 watt lamp	1	ELECT	Electronic Power Supply	75
	1	75 watt lamp	1	ELECT	Electronic Power Supply	80
	1	100 watt lamp	1	ELECT	Electronic Power Supply	106
	1	20 watt lamp	1	MAG	Mag. Transformer	24
	1	25 watt lamp	1	MAG	Mag. Transformer	29
	1	35 watt lamp	1	MAG	Mag. Transformer	39
	1	37 watt lamp	1	MAG	Mag. Transformer	42
	1	42 watt lamp	1	MAG	Mag. Transformer	46
	1	50 watt lamp	1	MAG	Mag. Transformer	55
	1	65 watt lamp	1	MAG	Mag. Transformer	70
	1	71 watt lamp	1	MAG	Mag. Transformer	76
	1	75 watt lamp	1	MAG	Mag. Transformer	81
	1	100 watt lamp	1	MAG	Mag. Transformer	108

Appendix B:

Materials Reference

Appendix B: Materials Reference

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CHAPTER 24

THERMAL AND WATER VAPOR TRANSMISSION DATA

<i>Building Envelopes</i>	24.1
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THIS chapter presents thermal and water vapor transmission data based on steady-state or equilibrium conditions. Chapter 3 covers heat transfer under transient or changing temperature conditions. Chapter 22 discusses selection of insulation materials and procedures for determining overall thermal resistances by simplified methods.

BUILDING ENVELOPES

Thermal Transmission Data for Building Components

The steady-state thermal resistances (R-values) of building components (walls, floors, windows, roof systems, etc.) can be calculated from the thermal properties of the materials in the component; or the heat flow through the assembled component can be measured directly with laboratory equipment such as the guarded hot box (ASTM Standard C 236) or the calibrated hot box (ASTM Standard C 976).

Tables 1 through 6 list thermal values, which may be used to calculate thermal resistances of building walls, floors, and ceilings. The values shown in these tables were developed under ideal conditions. In practice, overall thermal performance can be reduced significantly by such factors as improper installation and shrinkage, settling, or compression of the insulation (Tye and Desjarlais 1983; Tye 1985, 1986).

Most values in these tables were obtained by accepted ASTM test methods described in ASTM Standards C 177 and C 518 for materials and ASTM Standards C 236 and C 976 for building envelope components. Because commercially available materials vary, not all values apply to specific products.

The most accurate method of determining the overall thermal resistance for a combination of building materials assembled as a building envelope component is to test a representative sample by a hot box method. However, all combinations may not be conveniently or economically tested in this manner. For many simple constructions, calculated R-values agree reasonably well with values determined by hot box measurement.

The performance of materials fabricated in the field is especially subject to the quality of workmanship during construction and installation. Good workmanship becomes increasingly important as the insulation requirement becomes greater. Therefore, some engineers include additional insulation or other safety factors based on experience in their design.

Figure 1 shows how convection affects surface conductance of several materials. Other tests on smooth surfaces show that the average value of the convection part of the surface conductance decreases as the length of the surface increases.

Vapor retarders, which are discussed in Chapters 22 and 23, require special attention. Moisture from condensation or other sources may reduce the thermal resistance of insulation, but the effect of moisture must be determined for each material. For example, some materials with large air spaces are not affected signifi-

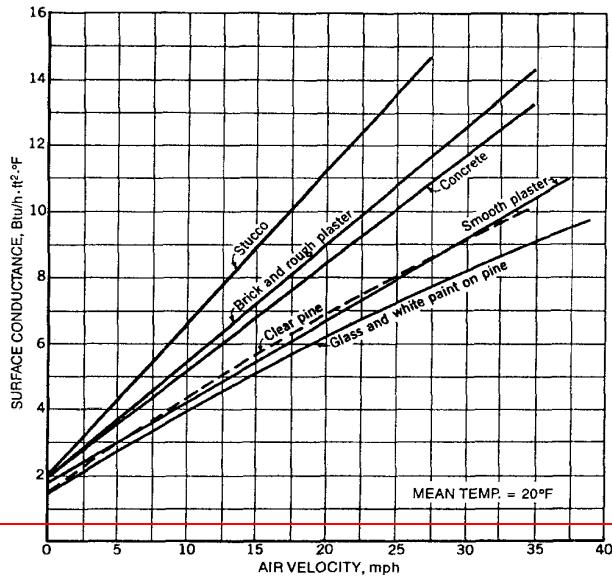


Fig. 1 Surface Conductance for Different Surfaces as Affected by Air Movement

cantly if the moisture content is less than 10% by weight, while the effect of moisture on other materials is approximately linear.

Ideal conditions of components and installations are assumed in calculating overall R-values (i.e., insulating materials are of uniform nominal thickness and thermal resistance, air spaces are of uniform thickness and surface temperature, moisture effects are not involved, and installation details are in accordance with design). The National Institute of Standards and Technology Building Materials and Structures Report BMS 151 shows that measured values differ from calculated values for certain insulated constructions. For this reason, some engineers decrease the calculated R-values a moderate amount to account for departures of constructions from requirements and practices.

Tables 3 and 2 give values for well-sealed systems constructed with care. Field applications can differ substantially from laboratory test conditions. Air gaps in these insulation systems can seriously degrade thermal performance as a result of air movement due to both natural and forced convection. Sabine et al. (1975) found that the tabular values are not necessarily additive for multiple-layer, low-emittance air spaces, and tests on actual constructions should be conducted to accurately determine thermal resistance values.

Values for foil insulation products supplied by manufacturers must also be used with caution because they apply only to systems that are identical to the configuration in which the product was tested. In addition, surface oxidation, dust accumulation, condensation, and other factors that change the condition of the low-emittance surface can reduce the thermal effectiveness of

The preparation of this chapter is assigned to TC 4.4, Thermal Insulation and Moisture Retarders.

24.2

Table 1 Surface Conductances and Resistances for Air

Position of Surface	Direction of Heat Flow	Surface Emittance, ϵ					
		Non-reflective $\epsilon = 0.90$		Reflective $\epsilon = 0.20$		Reflective $\epsilon = 0.05$	
		h_i	R	h_i	R	h_i	R
STILL AIR							
Horizontal	Upward	1.63	0.61	0.91	1.10	0.76	1.32
Sloping—45°	Upward	1.60	0.62	0.88	1.14	0.73	1.37
Vertical	Horizontal	1.46	0.68	0.74	1.35	0.59	1.70
Sloping—45°	Downward	1.32	0.76	0.60	1.67	0.45	2.22
Horizontal	Downward	1.08	0.92	0.37	2.70	0.22	4.55
MOVING AIR (Any position)							
15-mph Wind	Any	6.00	0.17	—	—	—	—
(for winter)							
7.5-mph Wind	Any	4.00	0.25	—	—	—	—
(for summer)							

Notes:

1. Surface conductance h_i and h_o measured in $\text{Btu}/(\text{h}\cdot\text{ft}^2\cdot^\circ\text{F})$; resistance R in $^\circ\text{F}\cdot\text{ft}^2\cdot\text{h/Btu}$.
2. No surface has both an air space resistance value and a surface resistance value.
3. For ventilated attics or spaces above ceilings under summer conditions (heat flow down), see Table 5.
4. Conductances are for surfaces of the stated emittance facing virtual blackbody surroundings at the same temperature as the ambient air. Values are based on a surface-air temperature difference of 10°F and for surface temperatures of 70°F.
5. See Chapter 3 for more detailed information, especially Tables 5 and 6, and see Figure 1 for additional data.
6. Condensate can have a significant impact on surface emittance (see Table 2).

these insulation systems (Hooper and Moroz 1952). Deterioration results from contact with several types of solutions, either acidic or basic (e.g., wet cement mortar or the preservatives found in decay-resistant lumber). Polluted environments may cause rapid and severe material degradation. However, site inspections show a predominance of well-preserved installations and only a small number of cases in which rapid and severe deterioration has occurred. An extensive review of the reflective building insulation system performance literature is provided by Goss and Miller (1989).

CALCULATING OVERALL THERMAL RESISTANCES

Relatively small, highly conductive elements in an insulating layer called thermal bridges can substantially reduce the average thermal resistance of a component. Examples include wood and metal studs in frame walls, concrete webs in concrete masonry walls, and metal ties or other elements in insulated wall panels. The following examples illustrate the calculation of R-values and U-factors for components containing thermal bridges.

These conditions are assumed in calculating the design R-values:

- Equilibrium or steady-state heat transfer, disregarding effects of thermal storage
- Surrounding surfaces at ambient air temperature
- Exterior wind velocity of 15 mph for winter (surface with $R = 0.17^\circ\text{F}\cdot\text{ft}^2\cdot\text{h/Btu}$) and 7.5 mph for summer (surface with $R = 0.25^\circ\text{F}\cdot\text{ft}^2\cdot\text{h/Btu}$)
- Surface emittance of ordinary building materials is 0.90

Wood Frame Walls

The average overall R-values and U-factors of wood frame walls can be calculated by assuming either parallel heat flow paths through areas with different thermal resistances or by assuming isothermal planes. Equations (1) through (5) from Chapter 22 are used.

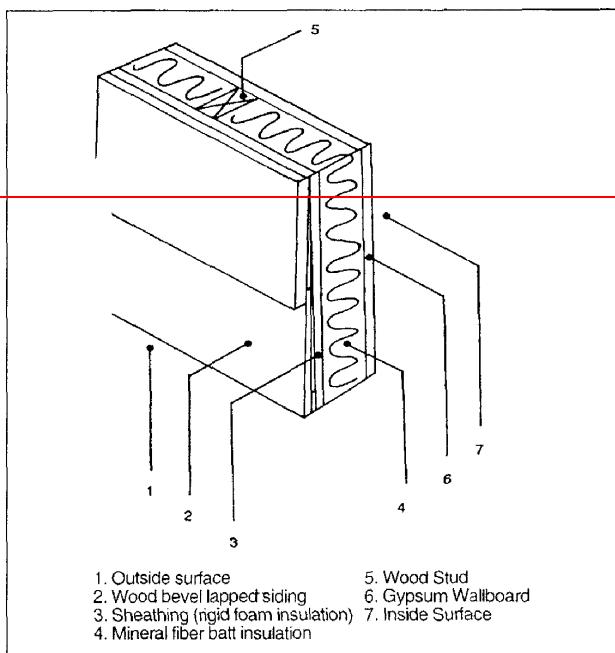
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Table 2 Emittance Values of Various Surfaces and Effective Emittances of Air Spaces^a

Surface	Average Emittance ϵ	Effective Emittance ϵ_{eff} of Air Space	
		One Surface Emittance ϵ	Both Surfaces ϵ ; Other, 0.9 Emittance ϵ
Aluminum foil, bright	0.05	0.05	0.03
Aluminum foil, with condensate just visible ($> 0.7 \text{ gr}/\text{ft}^2$)	0.30 ^b	0.29	—
Aluminum foil, with condensate clearly visible ($> 2.9 \text{ gr}/\text{ft}^2$)	0.70 ^b	0.65	—
Aluminum sheet	0.12	0.12	0.06
Aluminum coated paper, polished	0.20	0.20	0.11
Steel, galvanized, bright	0.25	0.24	0.15
Aluminum paint	0.50	0.47	0.35
Building materials: wood, paper, masonry, nonmetallic paints	0.90	0.82	0.82
Regular glass	0.84	0.77	0.72

^aThese values apply in the 4 to 40 μm range of the electromagnetic spectrum.

^bValues are based on data presented by Bassett and Trethewen (1984).

**Fig. 2 Insulated Wood Frame Wall (Example 1)**

The framing factor or fraction of the building component that is framing depends on the specific type of construction, and it may vary based on local construction practices—even for the same type of construction. For stud walls 16 in. on center (OC), the fraction of insulated cavity may be as low as 0.75, where the fraction of studs, plates, and sills is 0.21 and the fraction of headers is 0.04. For studs 24 in. OC, the respective values are 0.78, 0.18, and 0.04. These fractions contain an allowance for multiple studs, plates, sills, extra framing around windows, headers, and band joists. These assumed framing fractions are used in the following example, to illustrate the importance of including the effect of framing in determining the overall thermal conductance of a building. The actual framing fraction should be calculated for each specific construction.

Thermal and Water Vapor Transmission Data

24.3

Table 3 Thermal Resistances of Plane Air Spaces^{a,b,c}, °F·ft²·h/Btu

Position of Air Space	Direction of Heat Flow	Air Space		0.5-in. Air Space ^c					0.75-in. Air Space ^c				
		Mean Temp. ^d , °F	Temp. Diff. ^d , °F	0.03	0.05	0.2	0.5	0.82	0.03	0.05	0.2	0.5	0.82
Horiz.	Up	90	10	2.13	2.03	1.51	0.99	0.73	2.34	2.22	1.61	1.04	0.75
		50	30	1.62	1.57	1.29	0.96	0.75	1.71	1.66	1.35	0.99	0.77
		50	10	2.13	2.05	1.60	1.11	0.84	2.30	2.21	1.70	1.16	0.87
		0	20	1.73	1.70	1.45	1.12	0.91	1.83	1.79	1.52	1.16	0.93
		0	10	2.10	2.04	1.70	1.27	1.00	2.23	2.16	1.78	1.31	1.02
		-50	20	1.69	1.66	1.49	1.23	1.04	1.77	1.74	1.55	1.27	1.07
		-50	10	2.04	2.00	1.75	1.40	1.16	2.16	2.11	1.84	1.46	1.20
		90	10	2.44	2.31	1.65	1.06	0.76	2.96	2.78	1.88	1.15	0.81
45° Slope	Up	50	30	2.06	1.98	1.56	1.10	0.83	1.99	1.92	1.52	1.08	0.82
		50	10	2.55	2.44	1.83	1.22	0.90	2.90	2.75	2.00	1.29	0.94
		0	20	2.20	2.14	1.76	1.30	1.02	2.13	2.07	1.72	1.28	1.00
		0	10	2.63	2.54	2.03	1.44	1.10	2.72	2.62	2.08	1.47	1.12
		-50	20	2.08	2.04	1.78	1.42	1.17	2.05	2.01	1.76	1.41	1.16
		-50	10	2.62	2.56	2.17	1.66	1.33	2.53	2.47	2.10	1.62	1.30
		90	10	2.47	2.34	1.67	1.06	0.77	3.50	3.24	2.08	1.22	0.84
		50	30	2.57	2.46	1.84	1.23	0.90	2.91	2.77	2.01	1.30	0.94
Vertical	Horiz. →	50	10	2.66	2.54	1.88	1.24	0.91	3.70	3.46	2.35	1.43	1.01
		0	20	2.82	2.72	2.14	1.50	1.13	3.14	3.02	2.32	1.58	1.18
		0	10	2.93	2.82	2.20	1.53	1.15	3.77	3.59	2.64	1.73	1.26
		-50	20	2.90	2.82	2.35	1.76	1.39	2.90	2.83	2.36	1.77	1.39
		-50	10	3.20	3.10	2.54	1.87	1.46	3.72	3.60	2.87	2.04	1.56
		90	10	2.48	2.34	1.67	1.06	0.77	3.53	3.27	2.10	1.22	0.84
		50	30	2.64	2.52	1.87	1.24	0.91	3.43	3.23	2.24	1.39	0.99
		50	10	2.67	2.55	1.89	1.25	0.92	3.81	3.57	2.40	1.45	1.02
45° Slope	Down ↘	0	20	2.91	2.80	2.19	1.52	1.15	3.75	3.57	2.63	1.72	1.26
		0	10	2.94	2.83	2.21	1.53	1.15	4.12	3.91	2.81	1.80	1.30
		-50	20	3.16	3.07	2.52	1.86	1.45	3.78	3.65	2.90	2.05	1.57
		-50	10	3.26	3.16	2.58	1.89	1.47	4.35	4.18	3.22	2.21	1.66
		90	10	2.48	2.34	1.67	1.06	0.77	3.55	3.29	2.10	1.22	0.85
		50	30	2.66	2.54	1.88	1.24	0.91	3.77	3.52	2.38	1.44	1.02
		50	10	2.67	2.55	1.89	1.25	0.92	3.84	3.59	2.41	1.45	1.02
		0	20	2.94	2.83	2.20	1.53	1.15	4.18	3.96	2.83	1.81	1.30
Horiz.	Down ↘	0	10	2.96	2.85	2.22	1.53	1.16	4.25	4.02	2.87	1.82	1.31
		-50	20	3.25	3.15	2.58	1.89	1.47	4.60	4.41	3.36	2.28	1.69
		-50	10	3.28	3.18	2.60	1.90	1.47	4.71	4.51	3.42	2.30	1.71
Air Space		1.5-in. Air Space ^c					3.5-in. Air Space ^c						
Horiz.	Up	90	10	2.55	2.41	1.71	1.08	0.77	2.84	2.66	1.83	1.13	0.80
		50	30	1.87	1.81	1.45	1.04	0.80	2.09	2.01	1.58	1.10	0.84
		50	10	2.50	2.40	1.81	1.21	0.89	2.80	2.66	1.95	1.28	0.93
		0	20	2.01	1.95	1.63	1.23	0.97	2.25	2.18	1.79	1.32	1.03
		0	10	2.43	2.35	1.90	1.38	1.06	2.71	2.62	2.07	1.47	1.12
		-50	20	1.94	1.91	1.68	1.36	1.13	2.19	2.14	1.86	1.47	1.20
		-50	10	2.37	2.31	1.99	1.55	1.26	2.65	2.58	2.18	1.67	1.33
		90	10	2.92	2.73	1.86	1.14	0.80	3.18	2.96	1.97	1.18	0.82
45° Slope	Up	50	30	2.14	2.06	1.61	1.12	0.84	2.26	2.17	1.67	1.15	0.86
		50	10	2.88	2.74	1.99	1.29	0.94	3.12	2.95	2.10	1.34	0.96
		0	20	2.30	2.23	1.82	1.34	1.04	2.42	2.35	1.90	1.38	1.06
		0	10	2.79	2.69	2.12	1.49	1.13	2.98	2.87	2.23	1.54	1.16
		-50	20	2.22	2.17	1.88	1.49	1.21	2.34	2.29	1.97	1.54	1.25
		-50	10	2.71	2.64	2.23	1.69	1.35	2.87	2.79	2.33	1.75	1.39
		90	10	3.99	3.66	2.25	1.27	0.87	3.69	3.40	2.15	1.24	0.85
		50	30	2.58	2.46	1.84	1.23	0.90	2.67	2.55	1.89	1.25	0.91
Vertical	Horiz. →	50	10	3.79	3.55	2.39	1.45	1.02	3.63	3.40	2.32	1.42	1.01
		0	20	2.76	2.66	2.10	1.48	1.12	2.88	2.78	2.17	1.51	1.14
		0	10	3.51	3.35	2.51	1.67	1.23	3.49	3.33	2.50	1.67	1.23
		-50	20	2.64	2.58	2.18	1.66	1.33	2.82	2.75	2.30	1.73	1.37
		-50	10	3.31	3.21	2.62	1.91	1.48	3.40	3.30	2.67	1.94	1.50
		90	10	5.07	4.55	2.56	1.36	0.91	4.81	4.33	2.49	1.34	0.90
		50	30	3.58	3.36	2.31	1.42	1.00	3.51	3.30	2.28	1.40	1.00
		50	10	5.10	4.66	2.85	1.60	1.09	4.74	4.36	2.73	1.57	1.08
45° Slope	Down ↘	0	20	3.85	3.66	2.68	1.74	1.27	3.81	3.63	2.66	1.74	1.27
		0	10	4.92	4.62	3.16	1.94	1.37	4.59	4.32	3.02	1.88	1.34
		-50	20	3.62	3.50	2.80	2.01	1.54	3.77	3.64	2.90	2.05	1.57
		-50	10	4.67	4.47	3.40	2.29	1.70	4.50	4.32	3.31	2.25	1.68
		90	10	6.09	5.35	2.79	1.43	0.94	10.07	8.19	3.41	1.57	1.00
		50	30	6.27	5.63	3.18	1.70	1.14	9.60	8.17	3.86	1.88	1.22
		50	10	6.61	5.90	3.27	1.73	1.15	11.15	9.27	4.09	1.93	1.24
		0	20	7.03	6.43	3.91	2.19	1.49	10.90	9.52	4.87	2.47	1.62
Horiz.	Down ↘	0	10	7.31	6.66	4.00	2.22	1.51	11.97	10.32	5.08	2.52	1.64
		-50	20	7.73	7.20	4.77	2.85	1.99	11.64	10.49	6.02	3.25	2.18
		-50	10	8.09	7.52	4.91	2.89	2.01	12.98	11.56	6.36	3.34	2.22

^aSee Chapter 22, section Factors Affecting Heat Transfer across Air Spaces. Thermal resistance values were determined from the relation, $R = 1/C$, where $C = h_r + \epsilon_{eff}h_r$. h_r is the conduction-convection coefficient, ϵ_{eff} is the radiation coefficient $\approx 0.0068\epsilon_{eff}[(t_m + 460)/100]^3$, and t_m is the mean temperature of the air space. Values for h_r were determined from data developed by Robinson et al. (1954). Equations (5) through (7) in Yarbrough (1983) show the data in this table in analytic form. For extrapolation from this table to air spaces less than 0.5 in. (as in insulating window glass), assume $h_r = 0.159(1 + 0.0016t_m)/l$ where l is the air space thickness in inches, and h_r is heat transfer through the air space only.

^bValues are based on data presented by Robinson et al. (1954). (Also see Chapter 3, Tables 3 and 4, and Chapter 36). Values apply for ideal conditions, i.e., air spaces of uniform thickness bounded by plane, smooth, parallel surfaces with no air leakage to or from the space. When accurate values are required, use overall U-factors deter-

mined through calibrated hot box (ASTM C 976) or guarded hot box (ASTM C 236) testing. Thermal resistance values for multiple air spaces must be based on careful estimates of mean temperature differences for each air space.

^cA single resistance value cannot account for multiple air spaces; each air space requires a separate resistance calculation that applies only for the established boundary conditions. Resistances of horizontal spaces with heat flow downward are substantially independent of temperature difference.

^dInterpolation is permissible for other values of mean temperature, temperature difference, and effective emittance ϵ_{eff} . Interpolation and moderate extrapolation for air spaces greater than 3.5 in. are also permissible.

^eEffective emittance ϵ_{eff} of the air space is given by $1/\epsilon_{eff} = 1/\epsilon_1 + 1/\epsilon_2 - 1$, where ϵ_1 and ϵ_2 are the emittances of the surfaces of the air space (see Table 2).

24.4

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Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values^a

Description	Density, lb/ft ³	Conductivity ^b (k), Btu·in h·ft ² ·°F	Conductance (C), Btu h·ft ² ·°F	Resistance ^c (R)		Specific Heat, Btu lb·°F
				Per Inch Thickness (1/k), °F·ft ² ·h Btu·in	For Thickness Listed (1/C), °F·ft ² ·h Btu	
BUILDING BOARD						
Asbestos-cement board.....	120	4.0	—	0.25	—	0.24
Asbestos-cement board.....0.125 in.	120	—	33.00	—	0.03	
Asbestos-cement board.....0.25 in.	120	—	16.50	—	0.06	
Gypsum or plaster board.....0.375 in.	50	—	3.10	—	0.32	0.26
Gypsum or plaster board.....0.5 in.	50	—	2.22	—	0.45	
Gypsum or plaster board.....0.625 in.	50	—	1.78	—	0.56	
Plywood (Douglas Fir) ^d	34	0.80	—	1.25	—	0.29
Plywood (Douglas Fir).....0.25 in.	34	—	3.20	—	0.31	
Plywood (Douglas Fir).....0.375 in.	34	—	2.13	—	0.47	
Plywood (Douglas Fir).....0.5 in.	34	—	1.60	—	0.62	
Plywood (Douglas Fir).....0.625 in.	34	—	1.29	—	0.77	
Plywood or wood panels.....0.75 in.	34	—	1.07	—	0.93	0.29
Vegetable fiber board						
Sheathing, regular density ^e.....0.5 in.	18	—	0.76	—	1.32	0.31
.....0.78125 in.	18	—	0.49	—	2.06	
Sheathing intermediate density ^e.....0.5 in.	22	—	0.92	—	1.09	0.31
Nail-base sheathing ^e.....0.5 in.	25	—	0.94	—	1.06	0.31
Shingle backer.....0.375 in.	18	—	1.06	—	0.94	0.31
Shingle backer.....0.3125 in.	18	—	1.28	—	0.78	
Sound deadening board.....0.5 in.	15	—	0.74	—	1.35	0.30
Tile and lay-in panels, plain or acoustic.....0.5 in.	18	0.40	—	2.50	—	0.14
.....0.75 in.	18	—	0.80	—	1.25	
.....0.75 in.	18	—	0.53	—	1.89	
Laminated paperboard.....	30	0.50	—	2.00	—	0.33
Homogeneous board from repulpated paper.....	30	0.50	—	2.00	—	0.28
Hardboard ^f						
Medium density.....	50	0.73	—	1.37	—	0.31
High density, service-tempered grade and service grade.....	55	0.82	—	1.22	—	0.32
High density, standard-tempered grade.....	63	1.00	—	1.00	—	0.32
Particleboard ^g						
Low density.....	37	0.71	—	1.41	—	0.31
Medium density.....	50	0.94	—	1.06	—	0.31
High density.....	62	.5	1.18	—	0.85	—
Underlayment.....0.625 in.	40	—	1.22	—	0.82	0.29
Waferboard.....	37	0.63	—	1.59	—	
Wood subfloor.....0.75 in.	—	—	1.06	—	0.94	0.33
BUILDING MEMBRANE						
Vapor—permeable felt.....	—	—	16.70	—	0.06	
Vapor—seal, 2 layers of mopped 15-lb felt.....	—	—	8.35	—	0.12	
Vapor—seal, plastic film.....	—	—	—	—	Negl.	
FINISH FLOORING MATERIALS						
Carpet and fibrous pad.....	—	—	0.48	—	2.08	0.34
Carpet and rubber pad.....	—	—	0.81	—	1.23	0.33
Cork tile.....0.125 in.	—	—	3.60	—	0.28	0.48
Terrazzo.....1 in.	—	—	12.50	—	0.08	0.19
Tile—asphalt, linoleum, vinyl, rubber.....	—	—	20.00	—	0.05	0.30
vinyl asbestos.....	—	—	—	—	0.24	
ceramic.....	—	—	—	—	0.19	
Wood, hardwood finish.....0.75 in.	—	—	1.47	—	0.68	
INSULATING MATERIALS						
<i>Blanket and Batt^{f,g}</i>						
Mineral fiber, fibrous form processed from rock, slag, or glass						
approx. 3-4 in.....	0.4-2.0	—	0.091	—	11	
approx. 3.5 in.....	0.4-2.0	—	0.077	—	13	
approx. 3.5 in.....	1.2-1.6	—	0.067	—	15	
approx. 5.5-6.5 in.....	0.4-2.0	—	0.053	—	19	
approx. 5.5 in.....	0.6-1.0	—	0.048	—	21	
approx. 6-7.5 in.....	0.4-2.0	—	0.045	—	22	
approx. 8.25-10 in.....	0.4-2.0	—	0.033	—	30	
approx. 10-13 in.....	0.4-2.0	—	0.026	—	38	
<i>Board and Slabs</i>						
Cellular glass.....	8.0	0.33	—	3.03	—	0.18
Glass fiber, organic bonded.....	4.0-9.0	0.25	—	4.00	—	0.23
Expanded perlite, organic bonded.....	1.0	0.36	—	2.78	—	0.30
Expanded rubber (rigid).....	4.5	0.22	—	4.55	—	0.40
Expanded polystyrene, extruded (smooth skin surface) (CFC-12 exp.).....	1.8-3.5	0.20	—	5.00	—	0.29

Thermal and Water Vapor Transmission Data**24.5****Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values^a (Continued)**

Description	Density, lb/ft³	Conductivity^b (k), Btu·in h·ft²·°F	Conductance (C), Btu h·ft²·°F	Resistance^c (R)		Specific Heat, Btu lb·°F
				Per Inch Thickness (1/k), °F·ft²·h Btu·in	For Thickness Listed (1/C), °F·ft²·h Btu	
Expanded polystyrene, extruded (smooth skin surface) (HCFC-142b exp.) ^h	1.8-3.5	0.20	—	5.00	—	0.29
Expanded polystyrene, molded beads	1.0	0.26	—	3.85	—	—
	1.25	0.25	—	4.00	—	—
	1.5	0.24	—	4.17	—	—
	1.75	0.24	—	4.17	—	—
	2.0	0.23	—	4.35	—	—
Cellular polyurethane/polyisocyanurate ⁱ (CFC-11 exp.) (unfaced)	1.5	0.16-0.18	—	6.25-5.56	—	0.38
Cellular polyisocyanurate ^j (CFC-11 exp.) (gas-permeable facers)	1.5-2.5	0.16-0.18	—	6.25-5.56	—	0.22
Cellular polyisocyanurate ^j (CFC-11 exp.) (gas-impermeable facers)	2.0	0.14	—	7.04	—	0.22
Cellular phenolic (closed cell) (CFC-11, CFC-113 exp.) ^k	3.0	0.12	—	8.20	—	—
Cellular phenolic (open cell)	1.8-2.2	0.23	—	4.40	—	—
Mineral fiber with resin binder	15.0	0.29	—	3.45	—	0.17
Mineral fiberboard, wet felted						
Core or roof insulation	16-17	0.34	—	2.94	—	—
Acoustical tile	18.0	0.35	—	2.86	—	0.19
Acoustical tile	21.0	0.37	—	2.70	—	—
Mineral fiberboard, wet molded						
Acoustical tile ^l	23.0	0.42	—	2.38	—	0.14
Wood or cane fiberboard						
Acoustical tile ^l	0.5 in.	—	0.80	—	1.25	0.31
Acoustical tile ^l	0.75 in.	—	0.53	—	1.89	—
Interior finish (plank, tile)	15.0	0.35	—	2.86	—	0.32
Cement fiber slabs (shredded wood with Portland cement binder)	25-27.0	0.50-0.53	—	2.0-1.89	—	—
Cement fiber slabs (shredded wood with magnesia oxy sulfide binder)	22.0	0.57	—	1.75	—	0.31
Loose Fill						
Cellulosic insulation (milled paper or wood pulp)	2.3-3.2	0.27-0.32	—	3.70-3.13	—	0.33
Perlite, expanded	2.0-4.1	0.27-0.31	—	3.7-3.3	—	0.26
	4.1-7.4	0.31-0.36	—	3.3-2.8	—	—
	7.4-11.0	0.36-0.42	—	2.8-2.4	—	—
Mineral fiber (rock, slag, or glass) ^g						
approx. 3.75-5 in.	0.6-2.0	—	—	—	11.0	0.17
approx. 6.5-8.75 in.	0.6-2.0	—	—	—	19.0	—
approx. 7.5-10 in.	0.6-2.0	—	—	—	22.0	—
approx. 10.25-13.75 in.	0.6-2.0	—	—	—	30.0	—
Mineral fiber (rock, slag, or glass) ^g						
approx. 3.5 in. (closed sidewall application)	2.0-3.5	—	—	—	12.0-14.0	—
Vermiculite, exfoliated	7.0-8.2	0.47	—	2.13	—	0.32
	4.0-6.0	0.44	—	2.27	—	—
Spray Applied						
Polyurethane foam	1.5-2.5	0.16-0.18	—	6.25-5.56	—	—
Ureaformaldehyde foam	0.7-1.6	0.22-0.28	—	4.55-3.57	—	—
Cellulosic fiber	3.5-6.0	0.29-0.34	—	3.45-2.94	—	—
Glass fiber	3.5-4.5	0.26-0.27	—	3.85-3.70	—	—
Reflective Insulation						
Reflective material ($\epsilon < 0.5$) in center of 3/4 in. cavity forms two 3/8 in. vertical air spaces ^m	—	—	0.31	—	3.2	—
METALS						
(See Chapter 36, Table 3)						
ROOFING						
Asbestos-cement shingles	120	—	4.76	—	0.21	0.24
Asphalt roll roofing	70	—	6.50	—	0.15	0.36
Asphalt shingles	70	—	2.27	—	0.44	0.30
Built-up roofing	0.375 in.	70	—	3.00	—	0.33
Slate	0.5 in.	—	—	20.00	—	0.05
Wood shingles, plain and plastic film faced	—	—	1.06	—	0.94	0.31
PLASTERING MATERIALS						
Cement plaster, sand aggregate	116	5.0	—	0.20	—	0.20
Sand aggregate	0.375 in.	—	13.3	—	0.08	0.20
Sand aggregate	0.75 in.	—	6.66	—	0.15	0.20

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Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values^a (Continued)

Description	Density, lb/ft ³	Conductivity ^b (k), Btu·in h·ft ² ·°F	Conductance (C), Btu h·ft ² ·°F	Resistance ^c (R)		Specific Heat, Btu lb·°F
				Per Inch Thickness (1/k), °F·ft ² ·h Btu·in	For Thickness Listed (1/C), °F·ft ² ·h Btu	
Gypsum plaster:						
Lightweight aggregate	0.5 in.	45	—	3.12	—	0.32
Lightweight aggregate	0.625 in.	45	—	2.67	—	0.39
Lightweight aggregate on metal lath	0.75 in.	—	—	2.13	—	0.47
Perlite aggregate	45	1.5	—	0.67	—	0.32
Sand aggregate	105	5.6	—	0.18	—	0.20
Sand aggregate	0.5 in.	105	—	11.10	—	0.09
Sand aggregate	0.625 in.	105	—	9.10	—	0.11
Sand aggregate on metal lath	0.75 in.	—	—	7.70	—	0.13
Vermiculite aggregate	45	1.7	—	0.59	—	—
MASONRY MATERIALS						
<i>Masonry Units</i>						
Brick, fired clay	150	8.4-10.2	—	0.12-0.10	—	—
	140	7.4-9.0	—	0.14-0.11	—	—
	130	6.4-7.8	—	0.16-0.12	—	—
	120	5.6-6.8	—	0.18-0.15	—	0.19
	110	4.9-5.9	—	0.20-0.17	—	—
	100	4.2-5.1	—	0.24-0.20	—	—
	90	3.6-4.3	—	0.28-0.24	—	—
	80	3.0-3.7	—	0.33-0.27	—	—
	70	2.5-3.1	—	0.40-0.33	—	—
Clay tile, hollow						
1 cell deep	3 in.	—	—	1.25	—	0.80
1 cell deep	4 in.	—	—	0.90	—	1.11
2 cells deep.....	6 in.	—	—	0.66	—	1.52
2 cells deep.....	8 in.	—	—	0.54	—	1.85
2 cells deep.....	10 in.	—	—	0.45	—	2.22
3 cells deep.....	12 in.	—	—	0.40	—	2.50
Concrete blocks ^{n, o}						
Limestone aggregate						
8 in., 36 lb, 138 lb/ft ³ concrete, 2 cores	—	—	—	—	—	—
Same with perlite filled cores	—	—	0.48	—	2.1	—
12 in., 55 lb, 138 lb/ft ³ concrete, 2 cores	—	—	—	—	—	—
Same with perlite filled cores	—	—	0.27	—	3.7	—
Normal weight aggregate (sand and gravel)						
8 in., 33-36 lb, 126-136 lb/ft ³ concrete, 2 or 3 cores	—	—	0.90-1.03	—	1.11-0.97	0.22
Same with perlite filled cores	—	—	0.50	—	2.0	—
Same with vermiculite filled cores	—	—	0.52-0.73	—	1.92-1.37	—
12 in., 50 lb, 125 lb/ft ³ concrete, 2 cores	—	—	0.81	—	1.23	0.22
Medium weight aggregate (combinations of normal weight and lightweight aggregate)						
8 in., 26-29 lb, 97-112 lb/ft ³ concrete, 2 or 3 cores..	—	—	0.58-0.78	—	1.71-1.28	—
Same with perlite filled cores	—	—	0.27-0.44	—	3.7-2.3	—
Same with vermiculite filled cores	—	—	0.30	—	3.3	—
Same with molded EPS (beads) filled cores	—	—	0.32	—	3.2	—
Same with molded EPS inserts in cores.....	—	—	0.37	—	2.7	—
Lightweight aggregate (expanded shale, clay, slate or slag, pumice)						
6 in., 16-17 lb, 85-87 lb/ft ³ concrete, 2 or 3 cores....	—	—	0.52-0.61	—	1.93-1.65	—
Same with perlite filled cores	—	—	0.24	—	4.2	—
Same with vermiculite filled cores	—	—	0.33	—	3.0	—
8 in., 19-22 lb, 72-86 lb/ft ³ concrete	—	—	0.32-0.54	—	3.2-1.90	0.21
Same with perlite filled cores	—	—	0.15-0.23	—	6.8-4.4	—
Same with vermiculite filled cores	—	—	0.19-0.26	—	5.3-3.9	—
Same with molded EPS (beads) filled cores	—	—	0.21	—	4.8	—
Same with UF foam filled cores	—	—	0.22	—	4.5	—
Same with molded EPS inserts in cores.....	—	—	0.29	—	3.5	—
12 in., 32-36 lb, 80-90 lb/ft ³ concrete, 2 or 3 cores...	—	—	0.38-0.44	—	2.6-2.3	—
Same with perlite filled cores	—	—	0.11-0.16	—	9.2-6.3	—
Same with vermiculite filled cores	—	—	0.17	—	5.8	—
Stone, lime, or sand.....	180	72	—	0.01	—	—
Quartzitic and sandstone	160	43	—	0.02	—	—
	140	24	—	0.04	—	—
	120	13	—	0.08	—	0.19
Calcitic, dolomitic, limestone, marble, and granite	180	30	—	0.03	—	—
	160	22	—	0.05	—	—
	140	16	—	0.06	—	—
	120	11	—	0.09	—	0.19
	100	8	—	0.13	—	—

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Table 4 Typical Thermal Properties of Common Building and Insulating Materials—Design Values^a (Continued)

Description	Density, lb/ft ³	Conductivity ^b (k), Btu·in h·ft ² ·°F	Conductance (C), Btu h·ft ² ·°F	Resistance ^c (R)		Specific Heat, Btu lb·°F
				Per Inch Thickness (1/k), °F·ft ² ·h Btu·in	For Thickness Listed (1/C), °F·ft ² ·h Btu	
Gypsum partition tile						
3 by 12 by 30 in., solid.....	—	—	0.79	—	1.26	0.19
3 by 12 by 30 in., 4 cells.....	—	—	0.74	—	1.35	—
4 by 12 by 30 in., 3 cells.....	—	—	0.60	—	1.67	—
Concrete ^d						
Sand and gravel or stone aggregate concretes (concretes with more than 50% quartz or quartzite sand have conductivities in the higher end of the range).....	150 140 130 140 120 100	10.0-20.0 9.0-18.0 7.0-13.0 11.1 7.9 5.5	— — — — — —	0.10-0.05 0.11-0.06 0.14-0.08 0.09 0.13 0.18	— — — — — —	0.19-0.24
Limestone concretes	140 120 100	11.1 7.9 5.5	— — —	0.09 0.13 0.18	— — —	—
Gypsum-fiber concrete (87.5% gypsum, 12.5% wood chips).....	51	1.66	—	0.60	—	0.21
Cement/lime, mortar, and stucco	120 100 80	9.7 6.7 4.5	— — —	0.10 0.15 0.22	— — —	—
Lightweight aggregate concretes						
Expanded shale, clay, or slate; expanded slags; cinders; pumice (with density up to 100 lb/ft ³); and scoria (sanded concretes have conductivities in the higher end of the range).....	120 100 80 60 40	6.4-9.1 4.7-6.2 3.3-4.1 2.1-2.5 1.3	— — — — —	0.16-0.11 0.21-0.16 0.30-0.24 0.48-0.40 0.78	— — — — —	0.20 0.20
Perlite, vermiculite, and polystyrene beads	50 40 30 20	1.8-1.9 1.4-1.5 1.1 0.8	— — — —	0.55-0.53 0.71-0.67 0.91 1.25	— — — —	0.15-0.23
Foam concretes	120 100 80	5.4 4.1 3.0	— — —	0.19 0.24 0.33	— — —	—
Foam concretes and cellular concretes	70 60 40 20	2.5 2.1 1.4 0.8	— — — —	0.40 0.48 0.71 1.25	— — — —	—
SIDING MATERIALS (on flat surface)						
<i>Shingles</i>						
Asbestos-cement	120	—	4.75	—	0.21	—
Wood, 16 in., 7.5 exposure	—	—	1.15	—	0.87	0.31
Wood, double, 16-in., 12-in. exposure	—	—	0.84	—	1.19	0.28
Wood, plus ins. backer board, 0.312 in.	—	—	0.71	—	1.40	0.31
<i>Siding</i>						
Asbestos-cement, 0.25 in., lapped	—	—	4.76	—	0.21	0.24
Asphalt roll siding	—	—	6.50	—	0.15	0.35
Asphalt insulating siding (0.5 in. bed.)	—	—	0.69	—	1.46	0.35
Hardboard siding, 0.4375 in.	—	—	1.49	—	0.67	0.28
Wood, drop, 1 by 8 in.	—	—	1.27	—	0.79	0.28
Wood, bevel, 0.5 by 8 in., lapped	—	—	1.23	—	0.81	0.28
Wood, bevel, 0.75 by 10 in., lapped	—	—	0.95	—	1.05	0.28
Wood, plywood, 0.375 in., lapped	—	—	1.69	—	0.59	0.29
Aluminum, steel, or vinyl ^e , over sheathing						
Hollow-backed	—	—	1.64	—	0.61	0.29 ^f
Insulating-board backed nominal 0.375 in.	—	—	0.55	—	1.82	0.32
Insulating-board backed nominal 0.375 in., foil backed	—	—	0.34	—	2.96	—
Architectural (soda-lime float) glass.....	158	6.9	—	—	—	0.21
WOODS (12% moisture content)^g						
<i>Hardwoods</i>						0.39 ^s
Oak	41.2-46.8	1.12-1.25	—	0.89-0.80	—	
Birch	42.6-45.4	1.16-1.22	—	0.87-0.82	—	
Maple	39.8-44.0	1.09-1.19	—	0.92-0.84	—	
Ash	38.4-41.9	1.06-1.14	—	0.94-0.88	—	
<i>Softwoods</i>						0.39 ^s
Southern Pine	35.6-41.2	1.00-1.12	—	1.00-0.89	—	
Douglas Fir-Larch	33.5-36.3	0.95-1.01	—	1.06-0.99	—	
Southern Cypress	31.4-32.1	0.90-0.92	—	1.11-1.09	—	
Hem-Fir, Spruce-Pine-Fir	24.5-31.4	0.74-0.90	—	1.35-1.11	—	
West Coast Woods, Cedars	21.7-31.4	0.68-0.90	—	1.48-1.11	—	
California Redwood	24.5-28.0	0.74-0.82	—	1.35-1.22	—	

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Notes for Table 4

^aValues are for a mean temperature of 75°F. Representative values for dry materials are intended as design (not specification) values for materials in normal use. Thermal values of insulating materials may differ from design values depending on their in-situ properties (e.g., density and moisture content, orientation, etc.) and variability experienced during manufacture. For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests.

^bTo obtain thermal conductivities in Btu/h·ft·°F, divide the *k*-factor by 12 in/ft.

^cResistance values are the reciprocals of *C* before rounding off *C* to two decimal places.

^dLewis (1967).

^eU.S. Department of Agriculture (1974).

^fDoes not include paper backing and facing, if any. Where insulation forms a boundary (reflective or otherwise) of an airspace, see Tables 2 and 3 for the insulating value of an airspace with the appropriate effective emittance and temperature conditions of the space.

^gConductivity varies with fiber diameter. (See Chapter 22, Factors Affecting Thermal Performance.) Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Due to differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

^hThis material is relatively new and data are based on limited testing.

ⁱFor additional information, see Society of Plastics Engineers (SPE) *Bulletin U108*. Values are for aged, unfaced board stock. For change in conductivity with age of expanded polyurethane/polyisocyanurate, see Chapter 22, Factors Affecting Thermal Performance.

^jValues are for aged products with gas-impermeable facers on the two major surfaces. An aluminum foil facer of 0.001 in. thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded polyisocyanurate, see Chapter 22, Factors Affecting Thermal Performance, and SPE *Bulletin U108*.

^kCellular phenolic insulation may no longer be manufactured. The thermal conductivity and resistance values do not represent aged insulation, which may have a higher thermal conductivity and lower thermal resistance.

^lInsulating values of acoustical tile vary, depending on density of the board and on type, size, and depth of perforations.

^mCavity is framed with 0.75 in. wood furring strips. Caution should be used in applying this value for other framing materials. The reported value was derived from tests and applies to the reflective path only. The effect of studs or furring strips must be included in determining the overall performance of the wall.

ⁿValues for fully grouted block may be approximated using values for concrete with a similar unit weight.

^oValues for concrete block and concrete are at moisture contents representative of normal use.

^pValues for metal or vinyl siding applied over flat surfaces vary widely, depending on amount of ventilation of airspace beneath the siding; whether airspace is reflective or nonreflective; and on thickness, type, and application of insulating backing used. Values are averages for use as design guides, and were obtained from several guarded hot box tests (ASTM C 236) or calibrated hot box (ASTM C 976) on hollow-backed types and types made using backing-boards of wood fiber, foamed plastic, and glass fiber. Departures of ±50% or more from these values may occur.

^qVinyl specific heat = 0.25 Btu/lb·°F

^rSee Adams (1971), MacLean (1941), and Wilkes (1979). The conductivity values listed are for heat transfer across the grain. The thermal conductivity of wood varies linearly with the density, and the density ranges listed are those normally found for the wood species given. If the density of the wood species is not known, use the mean conductivity value. For extrapolation to other moisture contents, the following empirical equation developed by Wilkes (1979) may be used:

$$k = 0.1791 + \frac{(1.874 \times 10^{-2} + 5.753 \times 10^{-4} M)\rho}{1 + 0.01 M}$$

where *ρ* is density of the moist wood in lb/ft³, and *M* is the moisture content in percent.

^sFrom Wilkes (1979), an empirical equation for the specific heat of moist wood at 75°F is as follows:

$$c_p = \frac{(0.299 + 0.01 M)}{(1 + 0.01 M)} + \Delta c_p$$

where Δc_p accounts for the heat of sorption and is denoted by

$$\Delta c_p = M(1.921 \times 10^{-3} - 3.168 \times 10^{-5} M)$$

where *M* is the moisture content in percent by mass.

$$U_{av} = U_1 = \frac{1}{R_1} = 0.052 \text{ Btu/h} \cdot \text{ft}^2 \cdot \text{°F}$$

If the wood framing is accounted for using the parallel-path flow method, the U-factor of the wall is determined using Equation (5) from Chapter 22 as follows:

$$U_{av} = (0.75 \times 0.052) + (0.25 \times 0.095) = 0.063 \text{ Btu/h} \cdot \text{ft}^2 \cdot \text{°F}$$

If the wood framing is included using the isothermal planes method, the U-factor of the wall is determined using Equations (2) and (3) from Chapter 22 as follows:

$$\begin{aligned} R_{T(av)} &= 4.98 + 1/[(0.75/13.0) + (0.25/4.38)] + 1.13 \\ &= 14.82 \text{ °F} \cdot \text{ft}^2 \cdot \text{h/Btu} \\ U_{av} &= 0.067 \text{ Btu/h} \cdot \text{ft}^2 \cdot \text{°F} \end{aligned}$$

For a frame wall with a 24-in. OC stud space, the average overall R-value is 15.18°F·ft²·h/Btu. Similar calculation procedures may be used to evaluate other wall designs, except those with thermal bridges.

Masonry Walls

The average overall R-values of masonry walls can be estimated by assuming a combination of layers in series, one or more of which provides parallel paths. This method is used because heat flows laterally through block face shells so that transverse isothermal planes result. Average total resistance $R_{T(av)}$ is the sum of the resistances of

Element	<i>R</i> (Insulated Cavity)	<i>R</i> (Studs, Plates, and Headers)
1. Outside surface, 15 mphwind	0.17	0.17
2. Wood bevel lapped siding	0.81	0.81
3. Rigid foam insulating sheathing	4.0	4.0
4. Mineral fiber batt insulation, 3.5 in.	13.0	—
5. Wood stud, nominal 2 × 4	—	4.38
6. Gypsum wallboard, 0.5 in.	0.45	0.45
7. Inside surface, still air	0.68	0.68
$R_1 = 19.11$		$R_2 = 10.49$

Since the U-factor is the reciprocal of R-value, $U_1 = 0.052$ and $U_2 = 0.095 \text{ Btu/h} \cdot \text{ft}^2 \cdot \text{°F}$.

If the wood framing (thermal bridging) is not included, Equation (3) from Chapter 22 may be used to calculate the U-factor of the wall as follows:

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the layers between such planes, each layer calculated as shown in Example 2.

Example 2. Calculate the overall thermal resistance and average U-factor of the 7-5/8-in. thick insulated concrete block wall shown in Figure 3. The two-core block has an average web thickness of 1-in. and a face shell thickness of 1-1/4-in. Overall block dimensions are 7-5/8 by 7-5/8 by 15-5/8 in. Measured thermal resistances of 112 lb/ft³ concrete and 7 lb/ft³ expanded perlite insulation are 0.10 and 2.90°F·ft²·h/Btu per inch, respectively.

Solution. The equation used to determine the overall thermal resistance of the insulated concrete block wall is derived from Equations (2) and (5) from Chapter 22 and is given below:

$$R_{T(av)} = R_i + R_f + \left(\frac{a_w}{R_w} + \frac{a_c}{R_c} \right)^{-1} + R_o$$

where

$R_{T(av)}$ = overall thermal resistance based on assumption of isothermal planes

R_i = thermal resistance of inside air surface film (still air)

R_o = thermal resistance of outside air surface film (15 mph wind)

R_f = total thermal resistance of face shells

R_c = thermal resistance of cores between face shells

R_w = thermal resistance of webs between face shells

a_w = fraction of total area transverse to heat flow represented by webs of blocks

a_c = fraction of total area transverse to heat flow represented by cores of blocks

From the information given and the data in Table 1, determine the values needed to compute the overall thermal resistance.

$$R_i = 0.68$$

$$R_o = 0.17$$

$$R_f = (2)(1.25)(0.10) = 0.25$$

$$R_c = (5.125)(2.90) = 14.86$$

$$R_w = (5.125)(0.10) = 0.51$$

$$a_w = 3/15.625 = 0.192$$

$$a_c = 12.625/15.625 = 0.808$$

Using the equation given, the overall thermal resistance and average U-factor are calculated as follows:

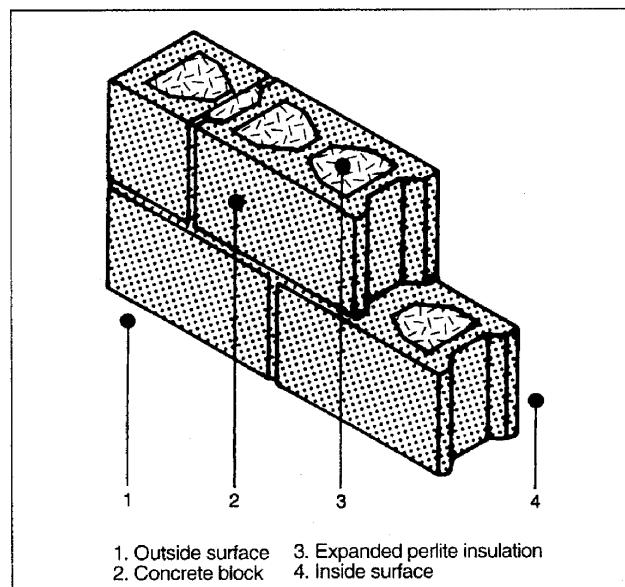


Fig. 3 Insulated Concrete Block Wall (Example 2)

$$\begin{aligned} R_{T(av)} &= 0.68 + 0.25 + \frac{0.51 \times 14.86}{(0.808 \times 0.51) + (0.192 \times 14.86)} + 0.17 \\ &= 3.43^{\circ}\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu} \\ U_{av} &= 1/3.43 = 0.29 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^{\circ}\text{F} \end{aligned}$$

Based on guarded hot box tests of this wall without mortar joints, Tye and Spinney (1980) measured the average R-value for this insulated concrete block wall as 3.13°F·ft²·h/Btu.

Assuming parallel heat flow only, the calculated resistance is higher than that calculated on the assumption of isothermal planes. The actual resistance generally is some value between the two calculated values. In the absence of test values, examination of the construction usually reveals whether a value closer to the higher or lower calculated R-value should be used. Generally, if the construction contains a layer in which lateral conduction is high compared with transmittance through the construction, the calculation with isothermal planes should be used. If the construction has no layer of high lateral conductance, the parallel heat flow calculation should be used.

Hot box tests of insulated and uninsulated masonry walls constructed with block of conventional configuration show that thermal resistances calculated using the isothermal planes heat flow method agree well with measured values (Van Geem 1985, Valore 1980, Shu et al. 1979). Neglecting horizontal mortar joints in conventional block can result in thermal transmittance values up to 16% lower than actual, depending on the density and thermal properties of the masonry, and 1 to 6% lower, depending on the core insulation material (Van Geem 1985, McIntyre 1984). For aerated concrete block walls, other solid masonry, and multicore block walls with full mortar joints, neglecting mortar joints can cause errors in R-values up to 40% (Valore 1988). Horizontal mortar joints usually found in concrete block wall construction are neglected in Example 2.

Constructions Containing Metal

Curtain and metal stud-wall constructions often include metallic and other thermal bridges, which can significantly reduce the thermal resistance. However, the capacity of the adjacent facing materials to transmit heat transversely to the metal is limited, and some contact resistance between all materials in contact limits the reduction. Contact resistances in building structures are only 0.06 to 0.6°F·ft²·h/Btu—too small to be of concern in many cases. However, the contact resistances of steel framing members may be important. Also, in many cases (as illustrated in Example 3), the area of metal in contact with the facing greatly exceeds the thickness of the metal, which mitigates the contact resistance effects.

Thermal characteristics for panels of sandwich construction can be computed by combining the thermal resistances of the various layers. However, few panels are true sandwich constructions; many have ribs and stiffeners that create complicated heat flow paths. R-values for the assembled sections should be determined on a representative sample by using a hot box method. If the sample is a wall section with air cavities on both sides of fibrous insulation, the sample must be of representative height since convective airflow can contribute significantly to heat flow through the test section. Computer modeling can also be useful, but all heat transfer mechanisms must be considered.

In Example 3, the metal member is only 0.020 in. thick, but it is in contact with adjacent facings over a 1.25 in.-wide area. The steel member is 3.50 in. deep, has a thermal resistance of approximately 0.011°F·ft²·h/Btu, and is virtually isothermal. The calculation involves careful selection of the appropriate thickness for the steel member. If the member is assumed to be 0.020 in. thick, the fact that the flange transmits heat to the adjacent facing is ignored, and the heat flow through the steel is underestimated. If the member is assumed to be 1.25 in. thick, the heat flow through the steel is overestimated. In Example 3, the steel member behaves in much the

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same way as a rectangular member 1.25 in. thick and 3.50 in. deep with a thermal resistance of $(1.25/0.020) \times 0.011 = 0.69^{\circ}\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$ does. The Building Research Association of New Zealand (BRANZ) commonly uses this approximation.

Example 3. Calculate the C-factor of the insulated steel frame wall shown in Figure 4. Assume that the steel member has an R-value of $0.69^{\circ}\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$ and that the framing behaves as though it occupies approximately 8% of the transmission area.

Solution. Obtain the R-values of the various building elements from Table 4.

Element	R (Insul.)	R (Framing)
1. 0.5-in. gypsum wallboard	0.45	0.45
2. 3.5-in. mineral fiber batt insulation	11	—
3. Steel framing member	—	0.69
4. 0.5-in. gypsum wallboard	0.45	0.45
$R_1 = 11.90$		$R_2 = 1.59$

Therefore, $C_1 = 0.084$; $C_2 = 0.629 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^{\circ}\text{F}$.

If the steel framing (thermal bridging) is not considered, the C-factor of the wall is calculated using Equation (3) from Chapter 22 as follows:

$$C_{av} = C_1 = 1/R_1 = 0.084 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^{\circ}\text{F}$$

If the steel framing is accounted for using the parallel flow method, the C-factor of the wall is determined using Equation (5) from Chapter 22 as follows:

$$C_{av} = (0.92 \times 0.084) + (0.08 \times 0.629)$$

$$= 0.128 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^{\circ}\text{F}$$

$$R_{T(av)} = 7.81^{\circ}\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$$

If the steel framing is included using the isothermal planes method, the C-factor of the wall is determined using Equations (2) and (3) from Chapter 22 as follows:

$$R_{T(av)} = 0.45 + 1/[(0.92/11.00) + (0.08/0.69)] + 0.45$$

$$= 5.91^{\circ}\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$$

$$C_{av} = 0.169 \text{ Btu/h} \cdot \text{ft}^2 \cdot {}^{\circ}\text{F}$$

For this insulated steel frame wall, Farouk and Larson (1983) measured an average R-value of $6.61^{\circ}\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$.

In ASHRAE/IESNA Standard 90.1-1989, one method given for determining the thermal resistance of wall assemblies containing metal framing involves using a parallel path correction factor F_c , which is listed in Table 8C-2 of the standard. For 2 by 4 steel framing, 16 in. OC, $F_c = 0.50$. Using the correction factor method, an

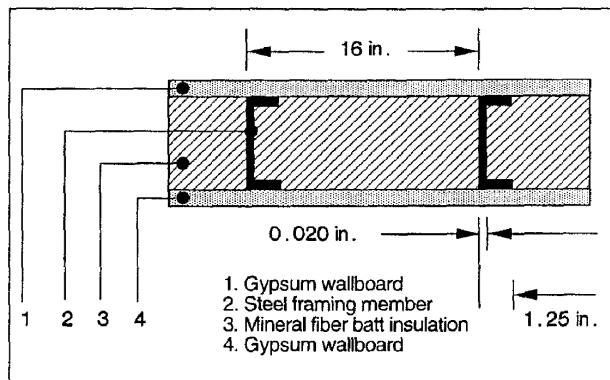


Fig. 4 Insulated Steel Frame Wall (Example 3)

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R-value of $6.40^{\circ}\text{F} \cdot \text{ft}^2 \cdot \text{h/Btu}$ [$0.45 + 11(0.50) + 0.45$] is obtained for the wall described in Example 3.

Zone Method of Calculation

For structures with widely spaced metal members of substantial cross-sectional area, calculation by the isothermal planes method can result in thermal resistance values that are too low. For these constructions, the **zone method** can be used. This method involves two separate computations—one for a chosen limited portion, Zone A, containing the highly conductive element; the other for the remaining portion of simpler construction, Zone B. The two computations are then combined using the parallel flow method, and the average transmittance per unit overall area is calculated. The basic laws of heat transfer are applied by adding the area conductances CA of elements in parallel, and adding area resistances R/A of elements in series.

The surface shape of Zone A is determined by the metal element. For a metal beam (see Figure 5), the Zone A surface is a strip of width W that is centered on the beam. For a rod perpendicular to panel surfaces, it is a circle of diameter W . The value of W is calculated from Equation (1), which is empirical. The value of d should not be less than 0.5 in. for still air.

$$W = m + 2d \quad (1)$$

where

m = width or diameter of metal heat path terminal, in.

d = distance from panel surface to metal, in.

Generally, the value of W should be calculated using Equation (1) for each end of the metal heat path; the larger value, within the limits of the basic area, should be used as illustrated in Example 4.

Example 4. Calculate transmittance of the roof deck shown in Figure 5.

Tee-bars at 24 in. OC support glass fiber form boards, gypsum concrete, and built-up roofing. Conductivities of components are: steel, $314.4 \text{ Btu} \cdot \text{in}/\text{h} \cdot {}^{\circ}\text{F}$; gypsum concrete, $1.66 \text{ Btu} \cdot \text{in}/\text{h} \cdot {}^{\circ}\text{F}$; and glass fiber form board, $0.25 \text{ Btu} \cdot \text{in}/\text{h} \cdot {}^{\circ}\text{F}$. Conductance of built-up roofing is $3.00 \text{ Btu} \cdot \text{h}/\text{ft}^2 \cdot {}^{\circ}\text{F}$.

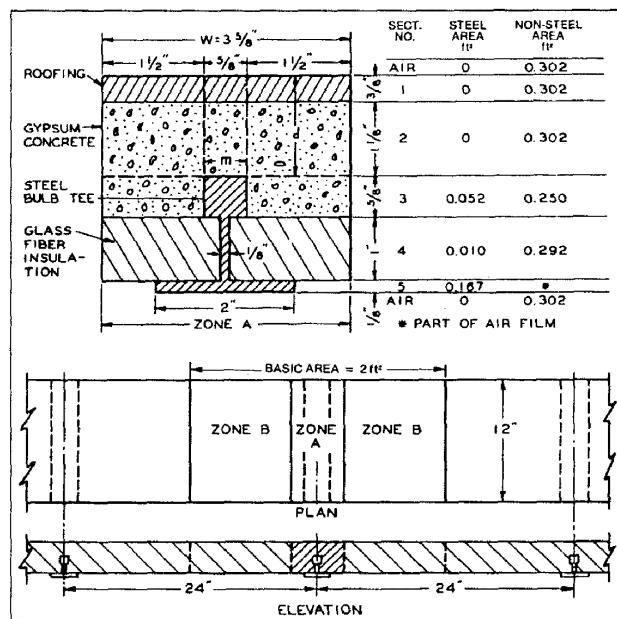


Fig. 5 Gypsum Roof Deck on Bulb Tees (Example 4)

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Solution. The basic area is 2 ft² (24 in. by 12 in.) with a tee-bar (12 in. long) across the middle. This area is divided into Zones A and B.

Zone A is determined from Equation (1) as follows:

$$\text{Top side } W = m + 2d = 0.625 + (2 \times 1.5) = 3.625 \text{ in.}$$

$$\text{Bottom side } W = m + 2d = 2.0 + (2 \times 0.5) = 3.0 \text{ in.}$$

Using the larger value of W , the area of Zone A is $(12 \times 3.625)/144 = 0.302 \text{ ft}^2$. The area of Zone B is $2.0 - 0.302 = 1.698 \text{ ft}^2$.

To determine area transmittance for Zone A, divide the structure within the zone into five sections parallel to the top and bottom surfaces (Figure 5). The area conductance CA of each section is calculated by adding the area conductances of its metal and nonmetal paths. Area conductances of the sections are converted to area resistances R/A and added to obtain the total resistance of Zone A.

Section	Area × Conductance = CA	$\frac{1}{CA} = \frac{R}{A}$
Air (outside, 15 mph)	0.302 × 6.00	1.81
No. 1, Roofing	0.302 × 3.00	0.906
No. 2, Gypsum concrete	0.302 × 1.66/1.125	0.446
No. 3, Steel	0.052 × 314.4/0.625	26.2
No. 3, Gypsum concrete	0.250 × 1.66/0.625	0.664
No. 4, Steel	0.010 × 314.4/1.00	3.14
No. 4, Glass fiberboard	0.292 × 0.25/1.00	0.073
No. 5, Steel	0.167 × 314.4/0.125	420.0
Air (inside)	0.302 × 1.63	0.492
	Total $R/A = 6.27$	2.03

$$\text{Area transmittance of Zone A} = 1/(R/A) = 1/6.27 = 0.159.$$

For Zone B, the unit resistances are added and then converted to area transmittance, as shown in the following table.

Section	Resistance, R
Air (outside, 15 mph)	1/6.00 = 0.17
Roofing	1/3.00 = 0.33
Gypsum concrete	1.75/1.66 = 1.05
Glass fiberboard	1.00/0.25 = 4.00
Air (inside)	1/1.63 = 0.61
Total resistance	= 6.16

Since unit transmittance = $1/R = 0.162$, the total area transmittance UA is calculated as follows:

$$\text{Zone B} = 1.698 \times 0.162 = 0.275$$

$$\text{Zone A} = 0.159$$

$$\text{Total area transmittance of basic area} = 0.434$$

$$\text{Transmittance per ft}^2 = 0.434/2.0 = 0.217$$

$$\text{Resistance per ft}^2 = 4.61$$

Overall R-values of 4.57 and 4.85°F·ft²·h/Btu have been measured in two guarded hot box tests of a similar construction.

When the steel member represents a relatively large proportion of the total heat flow path, as in Example 4, detailed calculations of resistance in sections 3, 4, and 5 of Zone A are unnecessary; if only the steel member is considered, the final result of Example 4 is the same. However, if the heat flow path represented by the steel member is small, as for a tie rod, detailed calculations for sections 3, 4, and 5 are necessary. A panel with an internal metallic structure and bonded on one or both sides to a metal skin or covering presents special problems of lateral heat flow not covered in the zone method.

Modified Zone Method for Metal Stud Walls with Insulated Cavities

The modified zone method is similar to the parallel path method and the zone method. All three methods are based on parallel-path calculations. Figure 6 shows the width w of the zone of thermal anomalies around a metal stud. This zone can be assumed to equal

the length of the stud flange L (parallel path method), or can be calculated as a sum of the length of stud flange and a distance double that from wall surface to metal Σd_i (zone method). In the modified zone method the width of the zone depends on the following three parameters:

- Ratio between thermal resistivity of sheathing material and cavity insulation
- Size (depth) of stud
- Thickness of sheathing material

The Modified Zone Method is explained in Figure 6 (which can be copied and used as a calculation form). The wall cross section shown in Figure 6, is divided into two zones: the zone of thermal anomalies around metal stud w and the cavity zone cav . Wall material layers are grouped into an exterior and interior surface sections—A (sheathing, siding) and B (wallboard)—and interstitial sections I and II (cavity insulation, metal stud flange).

Assuming that the layers or layer of wall materials in wall section A are thicker than those in wall section B, as show by the cross section in Figure 6, they can be described as follows:

$$\sum_{i=1}^n d_i \geq \sum_{j=1}^m d_j \quad (2)$$

where

n = number of material layer (of thickness d_i) between metal stud flange and wall surface for section A

m = number of material layer (of thickness d_j) for section B

Then, the width of the zone of thermal anomalies around the metal stud w can be estimated by

$$w = L + z_f \sum_{i=1}^n d_i \quad (3)$$

where

L = stud flange size,

d_i = thickness of material layer in section A

z_f = zone factor, which is shown in Figure 7 ($z_f = 2$ for zone method)

Kosny and Christian (1995) verified the accuracy of the Modified Zone Method for over 200 simulated cases of metal frame walls with insulated cavities. For all configurations considered the discrepancy between results were within $\pm 2\%$. Hot box measured R-values for 15 metal stud walls tested by Barbour et al. (1994) were compared with results obtained by Kosny and Christian (1995) and McGowan and Desjarlais (1997). The Modified Zone Method was found to be the most accurate simple method for estimating the clear wall R-value of light-gage steel stud walls with insulated cavities. However, this analysis does not apply to construction with metal sheathing. Also, ASHRAE Standard 90.1 may require a different method of analysis.

Ceilings and Roofs

The overall R-value for ceilings of wood frame flat roofs can be calculated using Equations (1) through (5) from Chapter 22. Properties of the materials are found in Tables 1, 3, 2, and 4. The fraction of framing is assumed to be 0.10 for joists at 16 in. OC and 0.07 for joists at 24 in. OC. The calculation procedure is similar to that shown in Example 1. Note that if the ceiling contains plane air spaces (see Table 3), the resistance depends on the direction of heat flow, i.e., whether the calculation is for a winter (heat flow up) or summer (heat flow down) condition.

For ceilings of pitched roofs under winter conditions, calculate the R-value of the ceiling using the procedure for flat roofs. Table 5 can be used to determine the effective resistance of the

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Table 10 Typical Thermal Conductivity for Industrial Insulations at Various Mean Temperatures—Design Values^a

Material	Max. Temp., ^b °F	Typical Density, lb/ft ³	Typical Conductivity in Btu·in/h·ft ² ·°F at Mean Temp., °F														
			-100	-75	-50	-25	0	25	50	75	100	200	300	500	700	900	
BLANKETS AND FELTS																	
ALUMINOSILICATE FIBER																	
7 to 10 µm diameter fiber	1800	4									0.24	0.32	0.54	0.99	1.03		
	2000	6.8									0.25	0.30	0.48	0.78	0.95		
3 µm diameter fiber	2200	4									0.22	0.29	0.45	0.59	0.74		
MINERAL FIBER (Rock, slag, or glass)																	
Blanket, metal reinforced	1200	6-12									0.26	0.32	0.39	0.54			
	1000	2.5-6									0.24	0.31	0.40	0.61			
Blanket, flexible, fine-fiber organic bonded	350	0.75					0.25	0.26	0.28	0.30	0.33	0.36	0.53				
		0.75					0.24	0.25	0.27	0.29	0.32	0.34	0.48				
		1.0					0.23	0.24	0.25	0.27	0.29	0.32	0.43				
		1.5					0.21	0.22	0.23	0.25	0.27	0.28	0.37				
		2.0					0.20	0.21	0.22	0.23	0.25	0.26	0.33				
		3.0					0.19	0.20	0.21	0.22	0.23	0.24	0.31				
Blanket, flexible, textile fiber, organic bonded	350	0.65					0.27	0.28	0.29	0.30	0.31	0.32	0.50	0.68			
		0.75					0.26	0.27	0.28	0.29	0.31	0.32	0.48	0.66			
		1.0					0.24	0.25	0.26	0.27	0.29	0.31	0.45	0.60			
		1.5					0.22	0.23	0.24	0.25	0.27	0.29	0.39	0.51			
		3.0					0.20	0.21	0.22	0.23	0.24	0.25	0.32	0.41			
Felt, semirigid organic bonded	400	3.8									0.24	0.25	0.26	0.27	0.35	0.44	
Laminated and felted without binder	850	3	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.35	0.55				
	1200	7.5										0.35	0.45	0.60			
BLOCKS, BOARDS, AND PIPE INSULATION																	
MAGNESIA	600	11-12									0.35	0.38	0.42				
85% CALCIUM SILICATE	1200	11-15									0.38	0.41	0.44	0.52	0.62	0.72	
	1800	12-15											0.63	0.74	0.95		
CELLULAR GLASS	900	7.8-8.2	0.24	0.25	0.26	0.28	0.29	0.30	0.32	0.33	0.34	0.41	0.49	0.70	1.01		
DIATOMACEOUS SILICA	1600	21-22											0.64	0.68	0.72		
	1900	23-25											0.70	0.75	0.80		
MINERAL FIBER (Glass)																	
Organic bonded block and boards	400	3-10	0.16	0.17	0.18	0.19	0.20	0.22	0.24	0.25	0.26	0.33	0.40				
	Nonpunking binder	1000	3-10								0.26	0.31	0.38	0.52			
	Pipe insulation, slag, or glass	350	3-4							0.20	0.21	0.22	0.23	0.24	0.29		
		500	3-10							0.20	0.22	0.24	0.25	0.26	0.33	0.40	
	Inorganic bonded block	1000	10-15								0.33	0.38	0.45	0.55			
		1800	15-24								0.32	0.37	0.42	0.52	0.62	0.74	
	Pipe insulation, slag, or glass	1000	10-15								0.33	0.38	0.45	0.55			
	Resin binder		15	0.23	0.24	0.25	0.26	0.28	0.29								
RIGID POLYSTYRENE																	
Extruded (CFC-12 exp.) (smooth skin surface)	165	1.8-3.5	0.16	0.16	0.17	0.16	0.17	0.18	0.19	0.20							
	Molded beads	165	1	0.17	0.19	0.20	0.21	0.22	0.24	0.25	0.26	0.28					
			1.25	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.27					
			1.5	0.16	0.17	0.19	0.20	0.21	0.22	0.23	0.24	0.26					
			1.75	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25					
			2.0	0.15	0.16	0.18	0.19	0.20	0.21	0.22	0.23	0.24					
RIGID POLYURETHANE/POLYISOCYANURATE ^{c,d}																	
Unfaced (CFC-11 exp.)	210	1.5-2.5	0.16	0.17	0.18	0.18	0.18	0.17	0.16	0.16	0.17						
Gas-impermeable facers (CFC-11 exp.)	250	2.0									0.12	0.13	0.14	0.15			
RIGID PHENOLIC																	
Closed cell (CFC-11, CFC-113 exp.)		3.0									0.11	0.115	0.12	0.125			
RUBBER, Rigid foamed	150	4.5									0.20	0.21	0.22	0.23			
VEGETABLE AND ANIMAL FIBER																	
Wool felt (pipe insulation)	180	20									0.28	0.30	0.31	0.33			
INSULATING CEMENTS																	
MINERAL FIBER (Rock, slag, or glass)																	
	With colloidal clay binder	1800	24-30									0.49	0.55	0.61	0.73	0.85	
	With hydraulic setting binder	1200	30-40									0.75	0.80	0.85	0.95		
LOOSE FILL																	
Cellulose insulation (milled pulverized paper or wood pulp)		2.5-3									0.26	0.27	0.29				
	Mineral fiber, slag, rock, or glass	2-5					0.19	0.21	0.23	0.25	0.26	0.28	0.31				
	Perlite (expanded)	3.5	0.22	0.24	0.25	0.27	0.28	0.30	0.31	0.33	0.35						
	Silica aerogel	7.6					0.13	0.14	0.15	0.15	0.16	0.17	0.18				
	Vermiculite (expanded)	7-8.2					0.39	0.40	0.42	0.44	0.45	0.47	0.49				
		4-6					0.34	0.35	0.38	0.40	0.42	0.44	0.46				

^aRepresentative values for dry materials, which are intended as design (not specification) values for materials in normal use. Insulation materials in actual service may have thermal values that vary from design values depending on their in-situ properties (e.g., density and moisture content). For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests.

^bThese temperatures are generally accepted as maximum. When operating temperature approaches these limits, follow the manufacturers' recommendations.

^cSome polyurethane foams are formed by means that produce a stable product (with respect to *k*), but most are blown with refrigerant and will change with time.

^dSee Table 4, footnote i.

^eSee Table 4, footnote j.

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Table 11A Heat Loss from Bare Steel Pipe to Still Air at 80°F^a, Btu/h·ft

Nominal Pipe Size ^b , in.	Pipe Inside Temperature, °F									
	180	280	380	480	580	680	780	880	980	1080
0.50	59.3	147.2	263.2	412.3	600.9	836.8	1128.6	1485.6	1918.0	2436.8
0.75	72.5	180.1	322.6	506.2	739.2	1031.2	1392.9	1836.0	2373.5	3018.8
1.00	88.8	220.8	396.1	622.7	910.9	1272.6	1721.2	2271.5	2939.4	3741.6
1.25	109.7	272.8	490.4	772.3	1131.7	1583.8	2145.6	2835.4	3673.4	4680.9
1.50	123.9	308.5	555.1	875.1	1283.8	1798.3	2438.2	3224.6	4180.5	5330.0
2.00	151.8	378.1	681.4	1076.3	1581.5	2218.9	3012.6	3989.2	5177.2	6606.8
2.50	180.5	450.0	811.9	1284.0	1888.8	2652.6	3604.3	4775.3	6199.5	7912.5
3.00	215.9	538.8	973.5	1541.8	2271.4	3194.0	4344.9	5762.2	7486.9	9562.3
3.50	243.9	609.0	1101.4	1746.1	2574.7	3623.6	4933.0	6546.4	8510.4	10874.3
4.00	271.6	678.6	1228.2	1948.7	2875.9	4050.5	5517.5	7326.0	9528.1	12178.9
4.50	299.2	747.7	1354.4	2150.9	3176.8	4477.7	6103.8	8109.5	10553.2	13496.2
5.00	329.8	824.7	1494.8	2375.4	3510.6	4950.7	6751.3	8972.5	11678.4	14936.3
6.00	387.1	968.7	1757.8	2796.8	4138.0	5841.4	7972.7	10603.1	13808.2	17667.6
7.00	440.5	1102.8	2003.0	3189.9	4723.9	6673.5	9114.2	12127.4	15799.4	20220.8
8.00	493.3	1235.7	2246.1	3580.0	5305.5	7500.0	10248.4	13642.2	17778.2	22758.0
9.00	545.9	1368.1	2488.8	3970.2	5888.7	8331.0	11392.1	15174.5	19787.1	25343.6
10.00	604.3	1514.8	2757.2	4400.7	6530.1	9241.1	12638.6	16835.1	21949.2	28104.9
11.00	656.0	1644.8	2995.5	4783.8	7102.1	10054.9	13756.2	18328.4	23900.3	30606.1
12.00	704.0	1762.3	3203.8	5104.9	7557.3	10661.8	14524.9	19256.7	24967.6	31766.8
14.00	771.0	1934.2	3525.9	5636.0	8373.9	11862.4	16235.5	21635.6	28212.3	36120.3
16.00	872.2	2189.0	3993.2	6387.4	9495.9	13458.0	18424.8	24556.6	32021.1	40990.7
18.00	972.5	2441.7	4456.7	7132.9	10609.4	15041.3	20596.7	27453.2	35795.6	45813.1
20.00	1072.1	2692.4	4916.8	7873.2	11715.1	16613.4	22752.5	30326.8	39537.6	50590.0
24.00	1269.3	3188.9	5828.3	9339.9	13905.5	19726.9	27019.7	36010.1	46930.3	60014.7

Table 11B Heat Loss from Flat Surfaces to Still Air at 80°F, Btu/h·ft²

	Surface Inside Temperature, °F									
	180	280	380	480	580	680	780	880	980	1080
Vertical surface	212.2	533.1	973.3	1558.6	2321.2	3298.0	4530.1	6062.8	7945.5	10231.5
Horizontal surface										
Facing up	234.7	586.4	1061.1	1683.5	2484.9	3501.9	4775.4	6350.4	8276.3	10606.1
Facing down	183.6	465.3	861.4	1399.6	2112.8	3038.4	4217.8	5696.7	7524.5	9754.7

^aCalculations from ASTM C 680; steel: $k = 314.4 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot {}^\circ\text{F}$; $\epsilon = 0.94$.

^bLosses per square foot of pipe for pipes larger than 24 in. can be considered the same as losses per square foot for 24-in. pipe.

cylindrical surfaces. Figure 9 shows surface resistance as a function of heat transmission for both flat and cylindrical surfaces. The surface emittance is assumed to be 0.85 to 0.90 in still air at 80°F.

Example 7. Compute the heat loss from a boiler wall if the interior insulation surface temperature is 1100°F and ambient still air temperature is 80°F. The wall is insulated with 4.5 in. of mineral fiber block and 0.5 in. of mineral fiber insulating and finishing cement.

Solution. Assume that the mean temperature of the mineral fiber block is 700°F, the mean temperature of the insulating cement is 200°F, and the surface resistance R_s is 0.60 ft²·°F·h/Btu.

From Table 10, $k_1 = 0.62$ and $k_2 = 0.80$. Using Equation (9) from Chapter 22:

$$q_s = \frac{1100 - 80}{(4.5/0.62) + (0.5/0.80) + 0.60} = 120.2 \text{ Btu}/\text{h} \cdot \text{ft}^2$$

As a check, from Figure 9, at 120.2 Btu/h·ft², $R_s = 0.56$. The mean temperature of the mineral fiber block is:

$$4.5/0.62 = 7.26; 7.26/2 = 3.63$$

$$1100 - \frac{3.63}{8.48}(1020) = 663^\circ\text{F}$$

and the mean temperature of the insulating cement is:

$$0.5/0.80 = 0.63; 0.63/2 = 0.31; 7.26 + 0.31 = 7.57$$

$$1100 - \frac{7.57}{8.48}(1020) = 189^\circ\text{F}$$

From Table 10, at 663°F, $k_1 = 0.60$; at 189°F, $k_2 = 0.79$.

Using these adjusted values to recalculate q_s :

$$q_s = \frac{1020}{(4.5/0.60) + (0.5/0.79) + 0.56} = \frac{1020}{8.69} = 117.4 \text{ Btu}/\text{h} \cdot \text{ft}^2$$

From Figure 9, at 117.4 Btu/h·ft², $R_s = 0.56$. The mean temperature of the mineral fiber block is:

$$4.5/0.6 = 7.50; 7.50/2 = 3.75$$

$$1100 - \frac{3.75}{8.69}(1020) = 660^\circ\text{F}$$

and the mean temperature of the insulating cement is:

$$0.5/0.79 = 0.63; 0.63/2 = 0.31; 7.50 + 0.31 = 7.81$$

$$1100 - \frac{7.81}{8.69}(1020) = 183^\circ\text{F}$$

From Table 10, at 660°F, $k_1 = 0.60$; at 183°F, $k_2 = 0.79$.

Since R_s , k_1 , and k_2 do not change at these values, $q_s = 117.4 \text{ Btu}/\text{h} \cdot \text{ft}^2$.

Example 8. Compute heat loss per square foot of outer surface of insulation if pipe temperature is 1200°F and ambient still air temperature is 80°F. The pipe is nominal 6-in. steel pipe, insulated with a nominal 3-in. thick diatomaceous silica as the inner layer and a nominal 2-in. thick calcium silicate as the outer layer.

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Table 12 Heat Loss from Bare Copper Tube to Still Air at 80°F^a, Btu/h·ft

Nominal Tube Size, in.	Tube Inside Temperature, °F							
	120	150	180	210	240	270	300	330
0.250	7.1	14.1	21.9	30.6	39.9	49.9	60.6	71.9
0.375	9.1	18.0	28.1	39.1	51.1	63.9	77.6	92.2
0.500	11.0	21.8	34.0	47.4	61.9	77.5	94.1	111.8
0.750	14.7	29.1	45.4	63.3	82.7	103.6	126.0	149.8
1.000	18.3	36.2	56.4	78.7	102.8	128.9	156.7	186.5
1.250	21.8	43.1	67.2	93.6	122.4	153.4	186.7	222.2
1.500	25.2	49.8	77.6	108.3	141.5	177.4	216.0	257.1
2.000	31.8	62.9	98.0	136.7	178.8	224.3	273.1	325.4
2.500	38.3	75.6	117.9	164.4	215.1	269.8	328.7	391.8
3.000	44.6	88.1	137.2	191.5	250.5	314.4	383.2	456.9
3.500	50.8	100.3	156.3	218.0	285.4	358.2	436.7	520.8
4.000	57.0	112.3	175.0	244.2	319.7	401.4	489.4	583.9
5.000	69.0	135.9	211.7	295.5	386.9	486.0	592.8	707.6
6.000	80.7	159.0	247.7	345.7	452.8	568.9	694.2	829.0
8.000	103.7	204.1	317.8	443.7	581.3	730.7	892.1	1066.0
10.000	126.1	247.9	386.1	539.1	706.5	888.4	1085.2	1297.4
12.000	148.0	290.9	453.0	632.5	829.2	1043.1	1274.6	1524.4
0.250	5.4	10.8	16.9	23.5	30.5	37.9	45.5	53.5
0.375	6.8	13.7	21.4	29.7	38.6	47.9	57.6	67.6
0.500	8.2	16.4	25.7	35.7	46.3	57.4	69.1	81.2
0.750	10.7	21.6	33.8	46.9	60.9	75.6	90.9	106.8
1.000	13.2	26.5	41.4	57.6	74.7	92.8	111.6	131.2
1.250	15.5	31.3	48.8	67.8	88.0	109.3	131.6	154.7
1.500	17.8	35.8	56.0	77.8	100.9	125.3	150.8	177.4
2.000	22.2	44.6	69.7	96.8	125.7	156.1	187.9	221.1
2.500	26.4	53.0	82.8	115.1	149.5	185.6	223.5	263.0
3.000	30.5	61.2	95.6	132.8	172.4	214.2	257.9	303.5
3.500	34.4	69.1	107.9	150.0	194.8	242.0	291.4	342.9
4.000	38.3	76.8	120.0	166.8	216.6	269.1	324.1	381.4
5.000	45.7	91.8	143.4	199.3	258.8	321.6	387.4	456.1
6.000	53.0	106.3	166.0	230.7	299.7	372.5	448.7	528.3
8.000	66.8	134.1	209.4	291.1	378.2	470.1	566.5	667.2
10.000	80.2	160.8	251.0	349.0	453.4	563.7	679.5	800.4
12.000	93.0	186.5	291.3	404.9	526.1	654.2	788.7	929.3

^aCalculations from ASTM C 680; for copper: $k = 2784 \text{ Btu} \cdot \text{in}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}$.

Solution. From Chapter 40 of the 1996 ASHRAE Handbook—Equipment, $r_o = 3.31 \text{ in}$. A nominal 3-in. thick diatomaceous silica insulation to fit a nominal 6-in. steel pipe is 3.02 in. thick. A nominal 2-in. thick calcium silicate insulation to fit over the 3.02-in. diatomaceous silica is 2.08 in. thick. Therefore, $r_i = 6.33 \text{ in}$. and $r_s = 8.41 \text{ in}$.

Assume that the mean temperature of the diatomaceous silica is 600°F, the mean temperature of the calcium silicate is 250°F and the surface resistance R_s is 0.50. From Table 10, $k_1 = 0.66$; $k_2 = 0.42$. By Equation (10) from Chapter 22:

$$q_s = \frac{1200 - 80}{[8.41 \ln(6.33/3.31)/0.66] + [8.41 \ln(8.41/3.31)/0.40] + 0.50} = \frac{1120}{(5.45/0.66) + (2.39/0.40) + 0.50} = 76.0 \text{ Btu}/\text{h} \cdot \text{ft}^2$$

From Figure 9, at 76.0 Btu/h·ft², $R_s = 0.60$. The mean temperature of the diatomaceous silica is:

$$5.45/0.66 = 8.26; 8.26/2 = 4.13$$

$$1200 - \frac{4.13}{14.83}(1120) = 888^\circ\text{F}$$

and the mean temperature of the calcium silicate is:

$$2.39/0.40 = 5.98; 5.98/2 = 2.99; 8.26 + 2.99 = 11.25$$

$$1200 - \frac{11.25}{14.83}(1120) = 350^\circ\text{F}$$

From Table 10, $k_1 = 0.72$; $k_2 = 0.46$. Recalculating:

$$q_s = \frac{1120}{(5.45/0.72) + (2.39/0.46) + 0.60} = 83.8 \text{ Btu}/\text{h} \cdot \text{ft}^2$$

From Figure 9 at 83.8 Btu/h·ft², $R_s = 0.59$. The mean temperature of the diatomaceous silica is:

$$5.45/0.72 = 7.57; 7.57/2 = 3.78$$

$$1200 - \frac{3.78}{13.36}(1120) = 883^\circ\text{F}$$

and the mean temperature of the calcium silicate is:

$$2.39/0.40 = 5.98; 5.98/2 = 2.99; 8.26 + 2.99 = 11.25$$

$$1200 - \frac{11.25}{14.83}(1120) = 350^\circ\text{F}$$

From Table 10, $k_1 = 0.72$; $k_2 = 0.46$. Recalculating:

$$2.39/0.46 = 5.20; 5.20/2 = 2.60; 7.57 + 2.60 = 10.17$$

$$1200 - \frac{10.17}{13.36}(1120) = 347^\circ\text{F}$$

Since R_s , k_1 , and k_2 do not change at 83.8 Btu/h·ft², this is q_s .

The heat flow per ft² of the inner surface of the insulation is:

$$q_o = q_s(r_s/r_o) = 83.8(8.41/3.31) = 213 \text{ Btu}/\text{h} \cdot \text{ft}^2$$

Table B-2: Framed Wall Assembly U-values

Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-Value	Metal Wall U-Value	Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-Value	Metal Wall U-Value
2x4 @ 16" O.C.	11 (compressed)	0	0.098	0.202	2x6 @ 16" O.C.	19 (compressed)	0	0.065	0.120
		4	0.068	0.112		4	4	0.058	0.098
		5	0.064	0.101		5	5	0.048	0.089
		7	0.056	0.084		7	7	0.043	0.075
		8.7	0.051	0.073		8.7	8.7	0.040	0.067
	13	0	0.088	0.195		21	0	0.059	0.157
		4	0.063	0.109		4	4	0.046	0.096
		5	0.059	0.099		5	5	0.044	0.088
		7	0.052	0.082		7	7	0.041	0.075
		8.7	0.048	0.072		8.7	8.7	0.037	0.066
	15	0	0.081	0.189		22 (compressed)	0	0.062	0.158
		4	0.059	0.108		4	4	0.048	0.097
		5	0.055	0.097		5	5	0.045	0.088
		7	0.049	0.077		7	7	0.041	0.075
		8.7	0.045	0.071		8.7	8.7	0.038	0.067
2x4 @ 24" O.C.	11	0	0.094	0.173		19 (compressed)	0	0.062	0.135
		4	0.066	0.102		4	4	0.048	0.088
		5	0.062	0.093		5	5	0.045	0.084
		7	0.055	0.078		7	7	0.042	0.070
		8.7	0.050	0.069		8.7	8.7	0.039	0.062
	13	0	0.085	0.165		21	0	0.056	0.130
		4	0.061	0.099		4	4	0.044	0.086
		5	0.057	0.090		5	5	0.042	0.079
		7	0.051	0.077		7	7	0.039	0.068
		8.7	0.047	0.068		8.7	8.7	0.036	0.061
	15	0	0.077	0.158		22 (compressed)	0	0.058	0.132
		4	0.056	0.097		4	4	0.046	0.086
		5	0.053	0.088		5	5	0.043	0.079
		7	0.047	0.071		7	7	0.040	0.068
		8.7	0.044	0.067		8.7	8.7	0.037	0.061

Table B-2 (cont'd): Framed Wall Assembly U-values

Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-Value	Metal Wall U-Value	Framing Type and Spacing	Framing Cavity R-Value	Insulated Sheathing R-Value	Wood Wall U-Value	Metal Wall U-Value
2x8 @ 16" O.C.	19	0	0.059	0.145	2x10 @ 16" O.C.	30	0	0.041	0.120
		4	0.047	0.092			4	0.035	0.081
		5	0.044	0.084			5	0.033	0.075
		7	0.041	0.072			7	0.031	0.065
		8.7	0.038	0.064			8.7	0.029	0.059
	22	0	0.054	0.140		38 (compressed)	0	0.040	0.119
		4	0.043	0.090			4	0.033	0.080
		5	0.041	0.082			5	0.032	0.074
		7	0.038	0.071			7	0.030	0.065
		8.7	0.035	0.063			8.7	0.028	0.058
2x8 @ 24" O.C.	25	0	0.050	0.136		30 (compressed)	0	0.039	0.099
		4	0.040	0.088			4	0.033	0.071
		5	0.038	0.081			5	0.032	0.066
		7	0.035	0.070			7	0.030	0.058
		8.7	0.033	0.062			8.7	0.028	0.053
	30 (compressed)	0	0.048	0.135		38	0	0.038	0.097
		4	0.039	0.088			4	0.032	0.070
		5	0.037	0.081			5	0.031	0.066
		7	0.035	0.070			7	0.029	0.058
		8.7	0.032	0.062			8.7	0.027	0.053
	19	0	0.056	0.122					
		4	0.045	0.082					
		5	0.043	0.076					
		7	0.040	0.066					
		8.7	0.037	0.059					
	22	0	0.051	0.117					
		4	0.041	0.080					
		5	0.040	0.074					
		7	0.036	0.064					
		8.7	0.034	0.058					
	25	0	0.047	0.113					
		4	0.038	0.078					
		5	0.037	0.072					
		7	0.034	0.063					
		8.7	0.032	0.057					
	30 (compressed)	0	0.046	0.112					
		4	0.037	0.077					
		5	0.036	0.072					
		7	0.034	0.063					
		8.7	0.031	0.057					

Table B-2a: Solar Heat Gain Coefficients Used for Exterior Shading¹

Exterior Shading Device	SHGC
Standard Bug Screens	0.76
Exterior Sunscreens with weave 53*16/inch	0.30
Louvered Sunscreens with louvers as wide as openings	0.27
Low Sun Angle (LSA) Louvered Sunscreens	0.13
Roll-down Awning	0.13
Roll Down Blinds or Slats	0.13
None (for skylights only)	1.00

1) ~~Exterior operable awnings (canvas, plastic or metal), except those that roll vertically down and cover the entire window, should be treated as overhangs for purposes of compliance with the Standards.~~

Table B-3: Metal Framing Factor

METAL FRAMING FACTORS				
Stud Spacing	Stud Depth	Insulation R-Value	Framing Factor	
16" o.c.	4"	R-7	0.522	
		R-11	0.403	
		R-13	0.362	
		R-15	0.328	
	6"	R-19	0.325	
		R-21	0.300	
		R-22	0.287	
		R-25	0.263	
24" o.c.	4"	R-7	0.577	
		R-11	0.458	
		R-13	0.415	
		R-15	0.379	
	6"	R-19	0.375	
		R-21	0.348	
		R-22	0.335	
		R-25	0.308	
<u>R-value calculation for Exterior Wall Assemblies with Metal Studs,</u> <u>July, 19, 1990, Staff Draft Docket 90-CON-1.</u>				
*Correction to metal framing factors applies to the entire assembly including: interior air films, interior surfaces, cavity/insulation, exterior surfaces, and exterior air films.				

Table B-4: Properties of Hollow Unit Masonry Walls

Type			Core Treatment		
			Solid Grout	Partly Grouted with UngROUTed Cells	
				Empty	Insulated
12"	LW-CMU	U	0.51	0.43	0.30
		Rw	2.0	2.3	3.3
		HC	23	14.8	14.8
	MW-CMU	U	0.54	0.46	0.33
		Rw	1.9	2.2	3.0
		HC	23.9	15.6	15.6
	NW-CMU	U	0.57	0.49	0.36
		Rw	1.8	2.0	2.8
		HC	24.8	16.5	16.5
10"	LW-CMU	U	0.55	0.46	0.34
		Rw	1.8	2.2	2.9
		HC	18.9	12.6	12.6
	MW-CMU	U	0.59	0.49	0.37
		Rw	1.7	2.1	2.7
		HC	19.7	13.4	13.4
	NW-CMU	U	0.62	0.52	0.41
		Rw	1.6	1.9	2.4
		HC	20.5	14.2	14.2
8"	LW-CMU	U	0.62	0.50	0.37
		Rw	1.6	2.0	2.7
		HC	15.1	9.9	9.9
	MW-CMU	U	0.65	0.53	0.41
		Rw	1.5	1.9	2.4
		HC	15.7	10.5	10.5
	NW-CMU	U	0.69	0.56	0.44
		Rw	1.4	1.8	2.3
		HC	16.3	11.1	11.1
6"	Clay-Unit	U	0.57	0.47	0.39
		Rw	1.8	2.1	2.6
		HC	15.1	11.4	11.4
6"	LW-CMU	U	0.68	0.54	0.44
		Rw	1.5	1.9	2.3
		HC	10.9	7.9	7.9

MW-CMU	U	0.72	0.58	0.48
	Rw	1.4	1.7	2.1
	HC	11.4	8.4	8.4
NW-CMU	U	0.76	0.61	0.52
	Rw	1.3	1.6	1.9
	HC	11.9	8.9	8.9
Clay-Unit	U	0.65	0.52	0.45
	Rw	1.5	1.9	2.2
	HC	11.1	8.6	8.6

Notes:~~LW-CMU is a Light Weight Concrete Masonry Unit per ASTM C 90, Calculated at 105 PCF density~~~~MW-CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90, Calculated at 115 PCF density~~~~NW-CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90, Calculated at 125 PCF density~~~~Clay-Unit is a Hollow Clay Unit per ASTM C 652, Calculated at 130 PCF density~~~~Values include air films on inner and outer surfaces.~~~~Calculations based on Energy Calculations and Data, CMACN, 1986~~~~Grouted Cells at 32" X 48" in Partly Grouted Walls~~~~Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada~~**Table B-5: Properties of Solid Unit Masonry and Solid Concrete Walls**

Type	Layer Thickness, inches											
	3	4	5	6	7	8	9	10	11	12		
LW-CMU	U	na	0.71	0.64	na							
	Rw	na	1.4	1.6	na							
	HC	na	7.00	8.75	na							
MW-CMU	U	na	0.76	0.70	na							
	Rw	na	1.3	1.4	na							
	HC	na	7.67	9.58	na							
NW-CMU	U	0.89	0.82	0.76	na							
	Rw	1.1	1.2	1.3	na							
	HC	6.25	8.33	10.42	na							
Clay-Brick	U	0.80	0.72	0.66	na							
	Rw	1.3	1.4	1.5	na							
	HC	6.30	8.40	10.43	na							
Concrete	U	0.96	0.94	0.86	0.82	0.78	0.74	0.71	0.68	0.65	0.63	
	Rw	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6	
	HC	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00	26.40	28.80	

Notes:

LW-CMU is a Light Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 105 PCF density

MW-CMU is a Medium Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 115 PCF density

NW-CMU is a Normal Weight Concrete Masonry Unit per ASTM C 90 or 55, Calculated at 125 PCF density

Clay Brick is a Clay Unit per ASTM C 62, Calculated at 130 PCF density

Concrete is structural poured or precast concrete, Calculated at 144 PCF density

Calculations based on Energy Calculations and Data, CMACN, 1986

Values include air films on inner and outer surfaces.

Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada

Table B-6: Effective R-values for Interior Insulation Layers on Structural Mass Walls

Type Actual Thickness	Frame	FURRING SPACE R-VALUE WITHOUT FRAMING EFFECTS																						
		0	4	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Any	None	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	
0.5"	Wood	1.3	1.3	1.9	2.4	2.7	na	na	na	na	na	na	na	na	na	na	na							
	Metal	0.9	0.9	1.1	1.1	1.2	na	na	na	na	na	na	na	na	na	na	na							
0.75"	Wood	1.4	1.4	2.1	2.7	3.1	3.5	3.8	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	
	Metal	1.0	1.0	1.3	1.4	1.5	1.5	1.6	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	
1.0"	Wood	1.3	1.5	2.2	2.9	3.4	3.9	4.3	4.6	4.9	na	na	na	na	na	na	na	na	na	na	na	na	na	
	Metal	1.0	1.1	1.4	1.6	1.7	1.8	1.8	1.9	1.9	na	na	na	na	na	na	na	na	na	na	na	na	na	
1.5"	Wood	1.3	1.5	2.4	3.1	3.8	4.4	4.9	5.4	5.8	6.2	6.5	6.8	7.1	na	na	na	na	na	na	na	na	na	na
	Metal	1.1	1.2	1.6	1.9	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7	na	na	na	na	na	na	na	na	na	na
2"	Wood	1.4	1.5	2.5	3.3	4.0	4.7	5.3	5.9	6.4	6.9	7.3	7.7	8.1	8.4	8.7	9.0	9.3	na	na	na	na	na	na
	Metal	1.1	1.2	1.7	2.1	2.3	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.4	na	na	na	na	na	na	na
2.5"	Wood	1.4	1.5	2.5	3.4	4.2	4.9	5.6	6.3	6.8	7.4	7.9	8.4	8.8	9.2	9.6	10.0	10.3	10.6	10.9	11.2	11.5	na	
	Metal	1.2	1.3	1.8	2.3	2.6	2.8	3.0	3.2	3.3	3.5	3.6	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.1	na	na
3"	Wood	1.4	1.5	2.5	3.5	4.3	5.1	5.8	6.5	7.2	7.8	8.3	8.9	9.4	9.9	10.3	10.7	11.1	11.5	11.9	12.2	12.5	12.9	na
	Metal	1.2	1.3	1.9	2.4	2.8	3.4	3.3	3.5	3.7	3.8	4.0	4.4	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	4.7	4.8	na
3.5"	Wood	1.4	1.5	2.6	3.5	4.4	5.2	6.0	6.7	7.4	8.1	8.7	9.3	9.8	10.4	10.9	11.3	11.8	12.2	12.6	13.0	13.4	13.8	na
	Metal	1.2	1.3	2.0	2.5	2.9	3.2	3.5	3.8	4.0	4.2	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.1	5.2	5.2	5.3	na
4"	Wood	1.4	1.6	2.6	3.6	4.5	5.3	6.1	6.9	7.6	8.3	9.0	9.6	10.2	10.8	11.3	11.9	12.4	12.8	13.3	13.7	14.2	14.6	na
	Metal	1.2	1.3	2.0	2.6	3.0	3.4	3.7	4.0	4.2	4.5	4.6	4.8	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.8	na
4.5"	Wood	1.4	1.6	2.6	3.6	4.5	5.4	6.2	7.1	7.8	8.5	9.2	9.9	10.5	11.2	11.7	12.3	12.8	13.3	13.8	14.3	14.8	15.2	na
	Metal	1.2	1.3	2.1	2.6	3.1	3.5	3.9	4.2	4.5	4.7	4.9	5.1	5.3	5.4	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	na
5"	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.3	7.2	8	8.7	9.4	10.1	10.8	11.5	12.1	12.7	13.2	13.8	14.3	14.8	15.3	15.8	na
	Metal	1.2	1.4	2.1	2.7	3.2	3.7	4.1	4.4	4.7	5.0	5.2	5.4	5.6	5.8	5.9	6.1	6.2	6.3	6.5	6.6	6.7	6.8	na
5.5"	Wood	1.4	1.6	2.6	3.6	4.6	5.5	6.4	7.3	8.1	8.9	9.6	10.3	11.0	11.7	12.4	13.0	13.6	14.2	14.7	15.3	15.8	16.3	na
	Metal	1.3	1.4	2.1	2.8	3.3	3.8	4.2	4.6	4.9	5.2	5.4	5.7	5.9	6.1	6.3	6.4	6.6	6.7	6.8	7.0	7.1	7.2	na

All furring thickness values given are actual dimensions

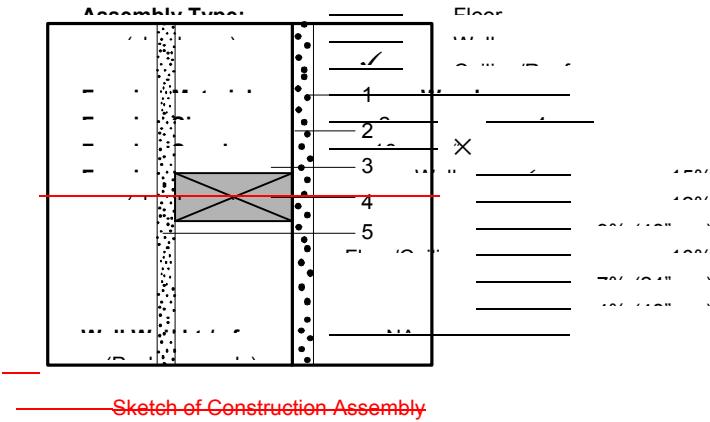
All values include .5" gypsum board on the inner surface, interior surface resistances not included

- 24" OC Furring
- 24 Gage, Z-type Metal Furring
- Douglas Fir Larch Wood Furring, density = 34.9 lb/cu.ft
- Insulation assumed to fill the furring space

[Source: Berkeley Solar Group; Concrete Masonry Association of California and Nevada]

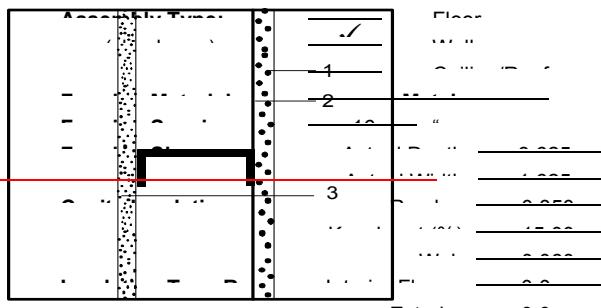
~~Table B-7: Framed Wall/Floor/Ceiling Assembly U-Values~~

Reference Name: W.0.2x4.16



~~Sketch of Construction Assembly~~

Reference Name: W.O.S2x4.16



~~Sketch of Construction Assembly~~

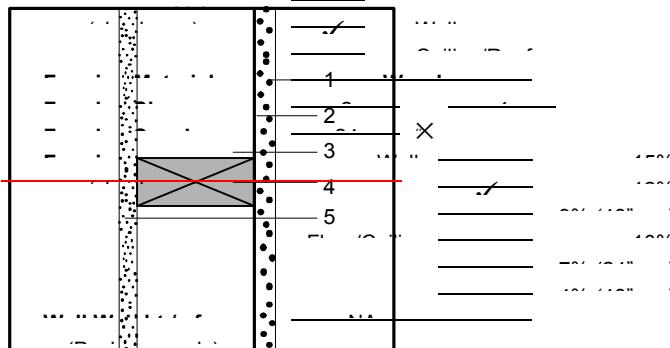
List of Construction Components

U-value	0.170

Calculation:
From EZFRAME =

Reference Name: W.0.2x4.24 2.23
1/0.449 =

Assembly 1. Total U- Total R-Value



Sketch of Construction Assembly

List of Construction Components

R-Value

Cavity (R _c)	Frame (R _f)
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170

Framing Adjustment Calculation:

$$\left[\frac{1}{1/2.390} \times \frac{(1-12/100)}{1-(Fr.\% \div 100)} \right] + \left[\frac{1}{1/5.005} \times \frac{(12/100)}{Fr.\% \div 100} \right] = \frac{0.392}{1/0.392} = \frac{2.549}{1 \div \text{Total U-}}$$

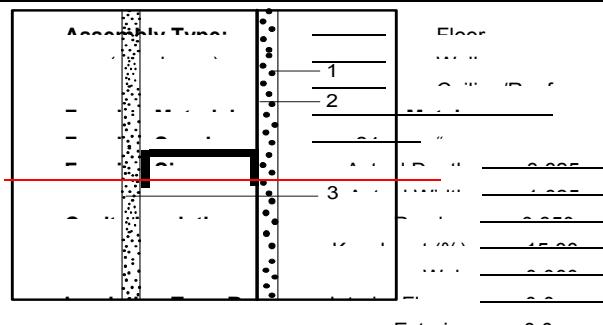
0.392

Total U

2.549

Total R-Value

Reference Name: W.0.S2x4.24



Sketch of Construction Assembly

List of Construction ComponentsR-ValueCavity (R_c)R_c

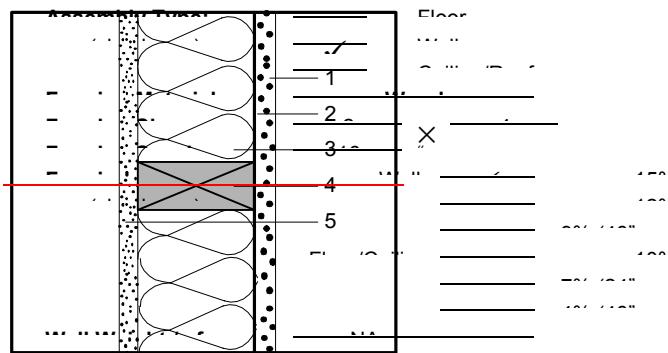
0.443Calculation:

From EZFRAME

Total R

2.260

1/0.443

Total R-ValueReference Name: W.7.2x4.16

Sketch of Construction Assembly

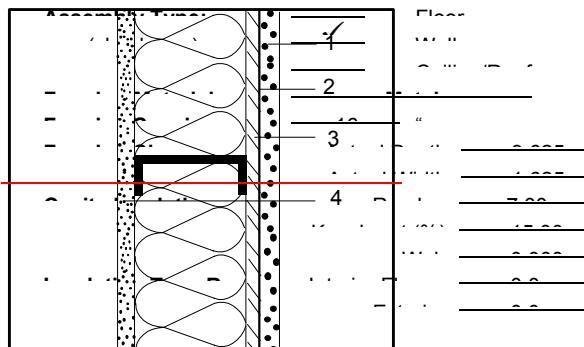
List of Construction ComponentsR-ValueCavity (R_c)R_cFrame (R_f)R_fR_f

c

f

Framing Adjustment Calculation:

$$\frac{[(\underline{1/8.540}) \times (\underline{1-15/100})] + [(\underline{1/5.005}) \times (\underline{15/100})]}{1-R_c \quad 1-(Fr.\% \div 100) \quad 1+R_f \quad Fr.\% \div 100} = \frac{0.130}{1/0.130} = \frac{7.69}{1 \div \text{Total U-Value}} = \frac{\text{Total R-Value}}{}$$

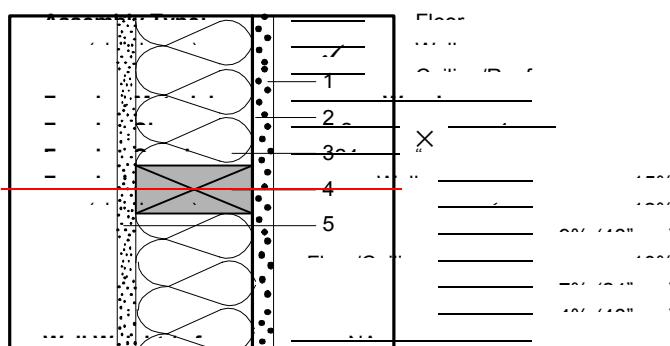
Reference Name: W.7.S2x4.16**Sketch of Construction Assembly****List of Construction Components****R-Value**

Stud	0.170

	0.170

Calculation:
From EZFRAME

$$\frac{0.170}{1/0.125} = \frac{7.990}{1 \div \text{Total U-Value}} = \frac{\text{Total R-Value}}{}$$

Reference Name: W.7.2x4.24**Sketch of Construction Assembly**

<u>List of Construction Components</u>	<u>R-Value</u>	
Cavity (R _c)	Frame (R _f)	
Cavity (R _c)	R _c	R _c
Frame (R _f)	R _f	R _f
Total U	U	U

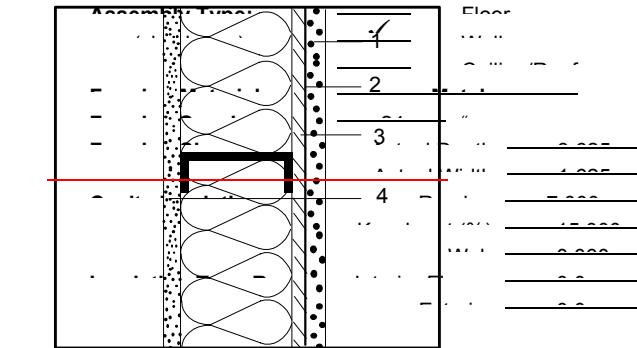
Framing Adjustment Calculation:

$$\frac{[(1/8.540) \times (1-12/100)]}{1+R_c} + \frac{[(1/5.005) \times (12/100)]}{1+R_f} = \frac{Fr.\% \div 100}{1/0.127} = \frac{0.127}{1+Total\ U}$$

Total U

Total R-Value

Reference Name: W.7.S2x4.24



Sketch of Construction Assembly

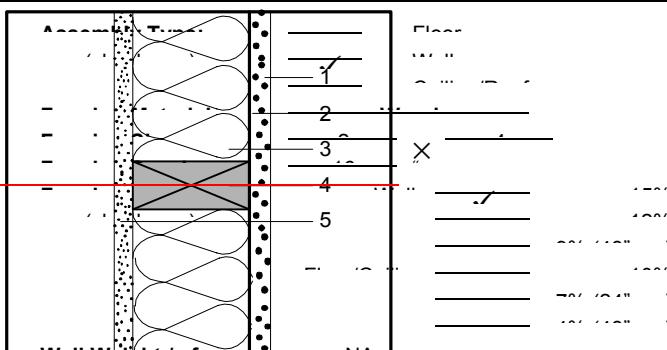
<u>List of Construction Components</u>	<u>R-Value</u>	
Cavity (R _c)	Frame (R _f)	
Cavity (R _c)	R _c	R _c
Frame (R _f)	R _f	R _f
Total U	U	U

Calculation:

$$\frac{\text{From EZFRAME}}{1/0.117} = \frac{0.117}{1+Total\ U} = \frac{Total\ U}{8.530}$$

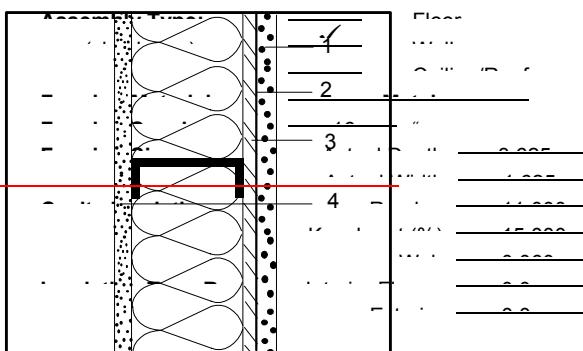
Total R-Value

Reference Name: W.11.2x4.16



Sketch of Construction Assembly

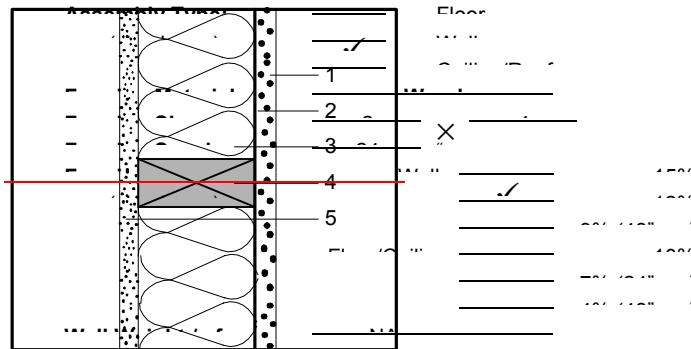
Reference Name: W.11.S2x4.16



Sketch of Construction Assembly

Calculation:
From EZFRAME

Reference Name: W 11.2x4.24



Sketch of Construction Assembly

List of Construction Components

R-Value

Gavity (R_g)

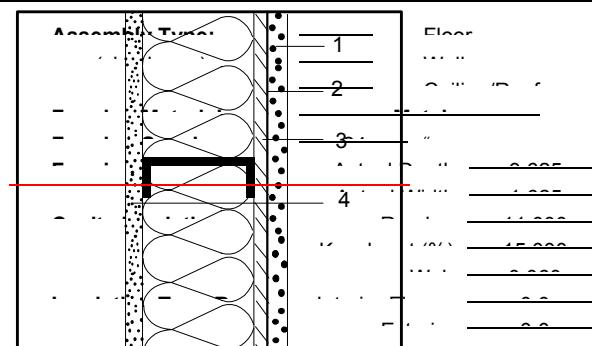
Frame (R_f)

1	0.170	0.170
2	0.170	0.170
3	0.170	0.170
4	0.170	0.170
5	0.170	0.170

Framing Adjustment Calculation:

$$\begin{array}{ccccccc} [(\frac{1}{12.540}) & & (\frac{1-12}{100})] & + & [(\frac{1}{5.005}) & & (\frac{12}{100})] \\ 1 \div R_g & & 1 - (Fr.\% \div 100) & & 1 \div R_f & & Fr.\% \div 100 \\ & & & & & & = \\ & & & & & & 1/0.094 \\ & & & & & & = \\ & & & & & & 10.638 \\ & & & & & & \\ & & & & & & \text{Total U-} \\ & & & & & & \\ & & & & & & \boxed{0.094} \\ & & & & & & \\ & & & & & & \text{Total R-Value} \\ & & & & & & \\ & & & & & & \end{array}$$

Reference Name: W.11.S2x4.24



Sketch of Construction Assembly

List of Construction ComponentsR-Value

Cavity (R-Value)

R-Value

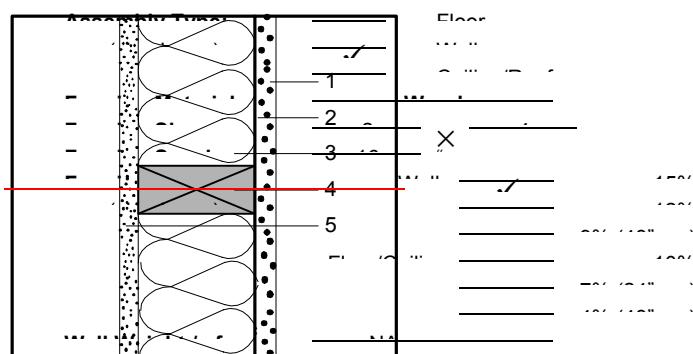
Calculation:

From EZFRAME

=

Total U

11.140

1/0.090Total R-Value0.0901÷Total U-
Reference Name: [W.13.2x4.16](#)

Sketch of Construction Assembly

List of Construction ComponentsR-ValueCavity (R_c)Frame (R_f)

Cavity (R-Value)

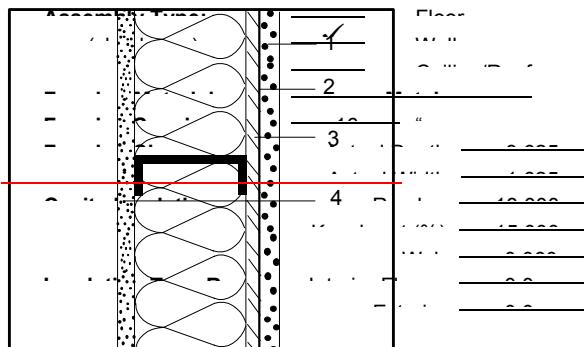
R-Value

0.1700.1700.1700.1700.1700.1700.1700.170**c****f**

Framing Adjustment Calculation:

$$\begin{array}{ccccc}
 [(\frac{1}{14.540})] & \times & [(\frac{1-15/100}{1-(Fr.\% \div 100)})] & + & [(\frac{1/5.005}{1 \div R_f})] \\
 1 \div R_c & & 1-(Fr.\% \div 100) & & Fr.\% \div 100 \\
 & & & & \\
 & & & & \hline
 & & & & 1/0.088 \\
 & & & = & \\
 & & & & 1 \div Total\ U- \\
 & & & & \\
 & & & & \hline
 & & & & 11.364 \\
 & & & & \\
 & & & & \boxed{0.088} \\
 & & & & Total\ U- \\
 & & & & 11.364 \\
 & & & & \\
 & & & & \boxed{0.088} \\
 & & & & Total\ R-Value
 \end{array}$$

Reference Name: W.13.S2x4.16



Sketch of Construction Assembly

Calculation:

From EZFRAME

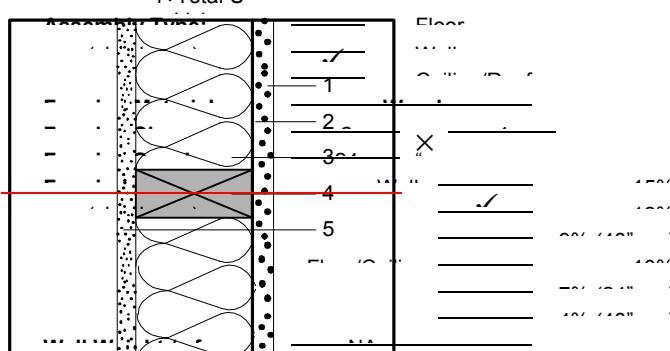
Total II

12 330

12.330

Reference Name: W.13.2x4.24

Total R-Value



Sketch of Construction Assembly

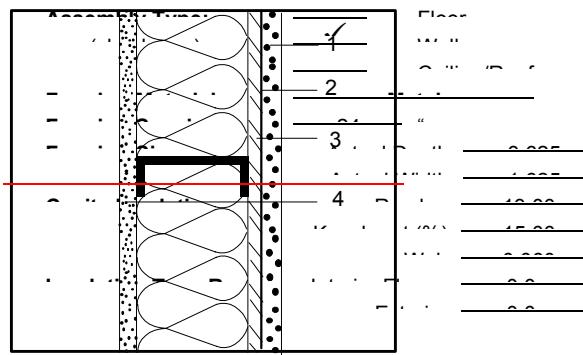
List of Construction Components	R-Value
Gavity (P _g)	Frame (P _f)
Roof (P _r)	Brickwork (P _b)

Category	R-Value	Category	R-Value

Framing Adjustment Calculation:

\times	$+$	$=$
$\frac{[(1/14.540) \times (1-12/100)]}{1+R_c}$	$\frac{[(1/5.005) \times (12/100)]}{1-(Fr.\% \div 100)}$	0.084
	$\frac{1+R_f}{Fr.\% \div 100}$	Total R-Value
	$\frac{1/0.084}{1+Total\ U-}$	11.905

Reference Name: W.13.S2x4.24



Sketch of Construction Assembly

List of Construction Components

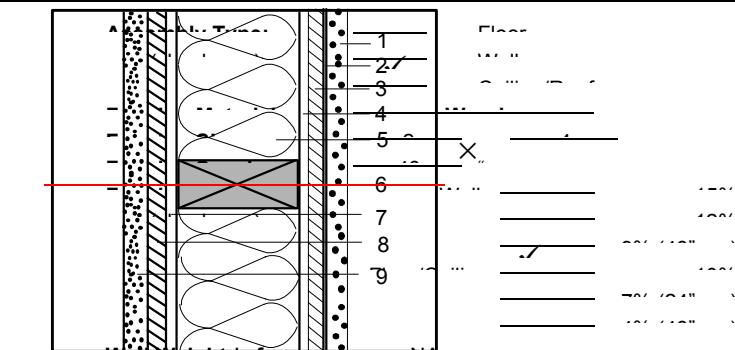
R-Value

Category	R-Value	Category	R-Value

Calculation:

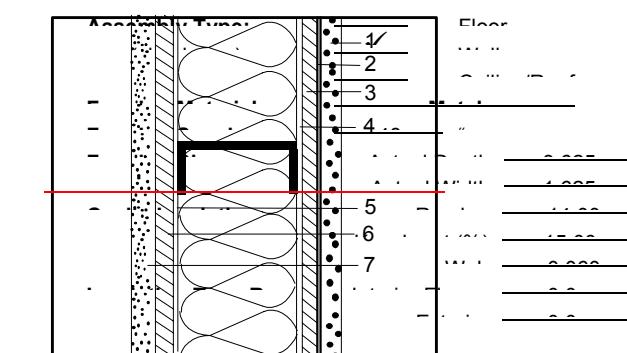
$\frac{From\ EZFRAME}{1/0.087}$	$=$
	0.087
	Total R-Value
	11.460

Reference Name: WP.14.2x4.48



~~Sketch of Construction Assembly~~

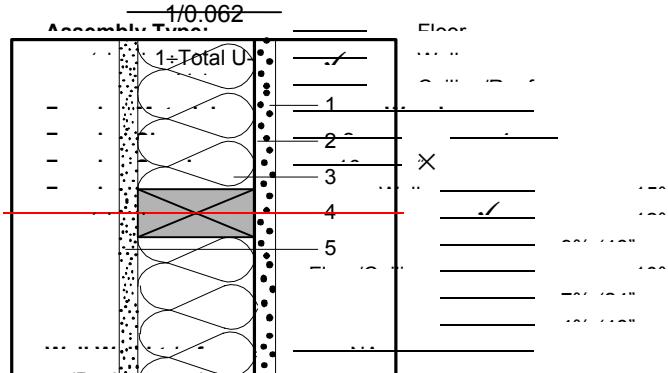
~~Reference Name:~~ WP 14 S2x448



Sketch of Construction Assembly

From EZFRAME =

Reference Name: W.15.2x4.16



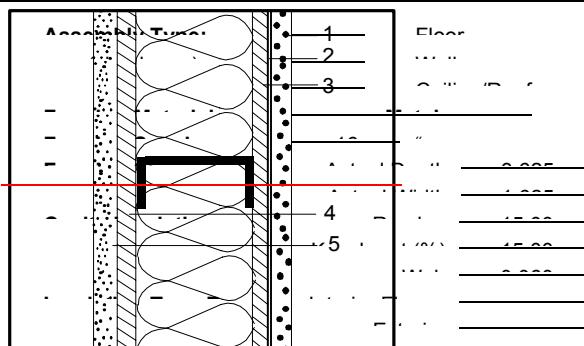
Sketch of Construction Assembly

List of Construction Components

R-Value

Framing Adjustment Calculation:					
$\left[\frac{1}{1/16.540} \right]$	\times	$\left(\frac{1-15/100}{1-(Fr.\% \div 100)} \right)$	$+$	$\left[\left(\frac{1}{5.005} \right) \times \left(\frac{15/100}{Fr.\% \div 100} \right) \right] =$	0.081
$1 \div R_c$		$1-(Fr.\% \div 100)$	$1 \div R_f$	$\underline{\underline{Fr.\% \div 100}}$	Total R-Value
				$=$	12.346
				$=$	Total R-Value

Reference Name: W.15.S2x4.16



Sketch of Construction Assembly

List of Construction ComponentsR-ValueCavity (R_c)R_c = 0.170

Calculation:

From EZFRAME

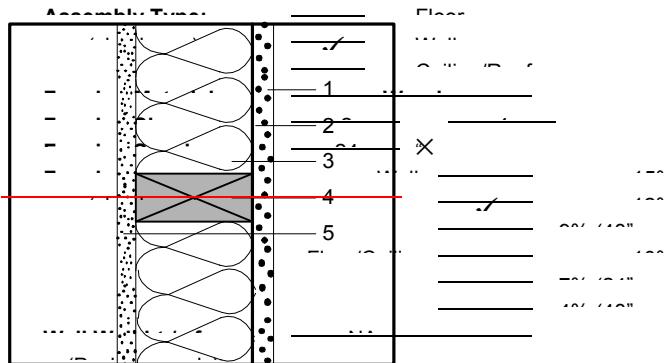
0.080

Total R

= 12.510

= Total R-Value

1/0.080

Reference Name: W.15.2x4.24

Sketch of Construction Assembly

List of Construction ComponentsR-ValueCavity (R_c)R_c = 0.170Frame (R_f)R_f = 0.170

c

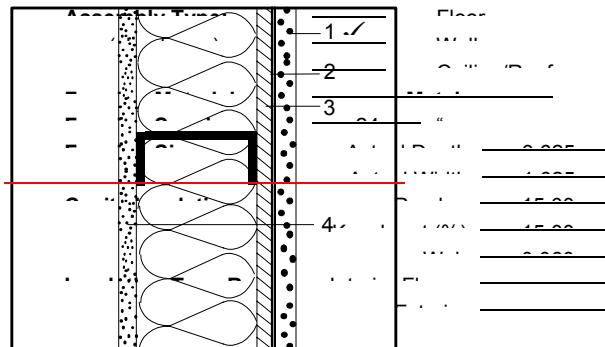
f

Framing Adjustment Calculation:

$$\frac{[(\underline{1/16.540}) \times (\underline{1-12/100})] + [(\underline{1/5.005}) \times (\underline{12/100})]}{1+R_c \quad 1-(Fr.\% \div 100) \quad 1+R_f \quad Fr.\% \div 100} = \frac{1/0.077}{1+Total U-} = \boxed{0.077}$$

Total U:
12.987
Total R-Value

Reference Name: W.15.S2x4.24



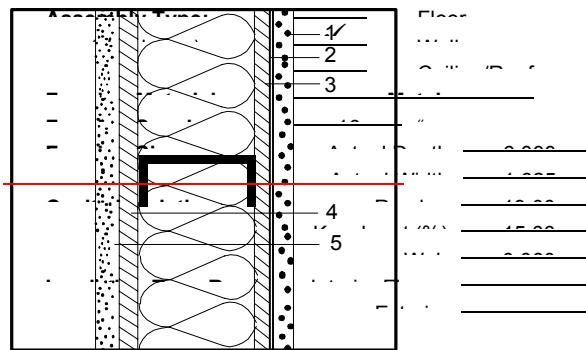
Sketch of Construction Assembly

List of Construction Components

R-Value

Component	R-Value
Component 1	
Component 2	
Component 3	
Component 4	
Component 5	
Component 6	
Component 7	
Component 8	
Component 9	
Component 10	
Component 11	
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Component 590	
Component 591	
Component 592	</

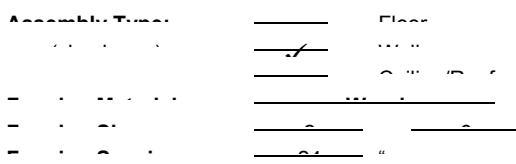
Reference Name: W.19.S2x6.16

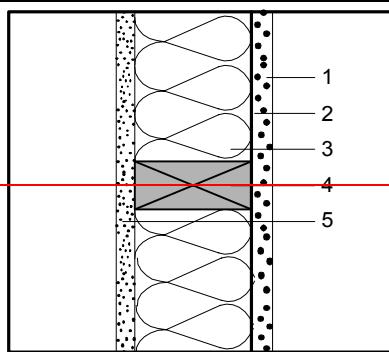


~~Sketch of Construction Assembly~~

List of Construction Components	R-Value
Ceiling	0.170
Walls	0.170
Floor	0.170
Glass	0.170
Doors	0.170
Total R-Value	0.064
	Total R-Value
=	15.530
	Total R-Value
	1/0.064

~~Reference Name:~~ W.19.2x6.24





Sketch of Construction Assembly

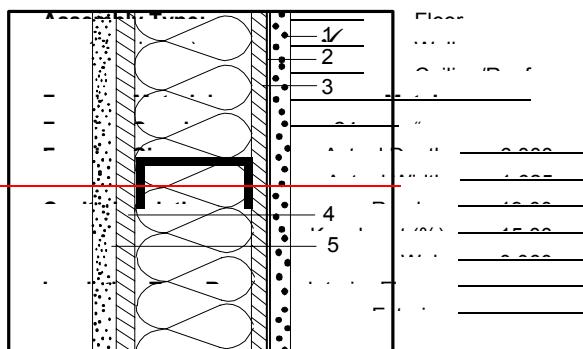
List of Construction ComponentsR-Value

<u>Cavity (R_c)</u>	<u>Frame (R_f)</u>

Framing Adjustment Calculation:

$$\frac{[(1/20.540) \times (1-12/100)]}{1+R_c} + \frac{[(1/6.985) \times (12/100)]}{1+R_f} = \frac{Fr.\% \div 100}{1/0.060} = \frac{0.060}{1+Total\ U-} = \frac{Total\ U}{16.666}$$

Total R-Value

Reference Name: W.19.S2x6.24

Sketch of Construction Assembly

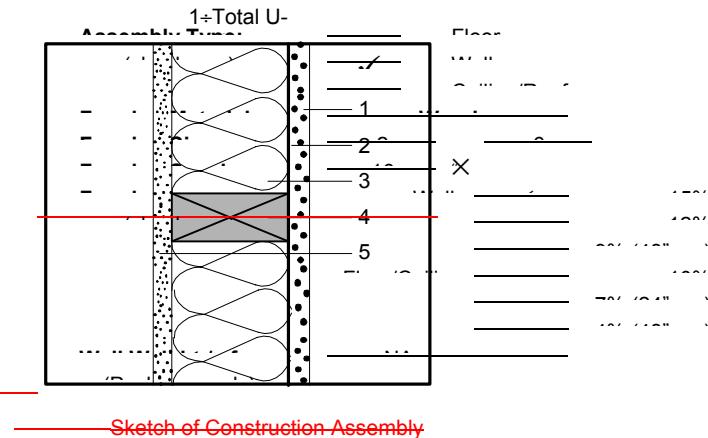
List of Construction ComponentsR-Value

<u>Cavity (R_c)</u>	<u>Frame (R_f)</u>

~~Calculation:~~

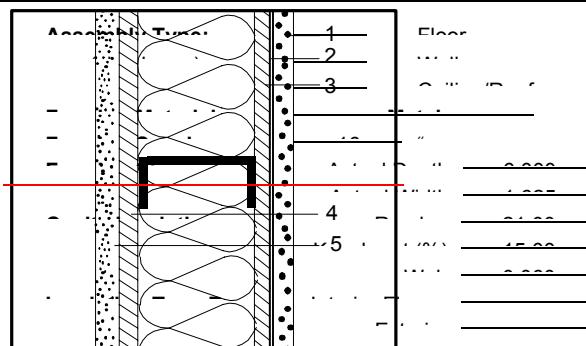
二

Reference Name: W.21.2x6.16



Framing Adjustment Calculation:					0.059
$\left[\left(\frac{1}{22.540} \right) \times \left(\frac{1-15/100}{1-(Fr.\% \div 100)} \right) \right] + \frac{\left[\left(\frac{1}{6.985} \right) \times \left(\frac{15/100}{Fr.\% \div 100} \right) \right]}{1+R_f}$					Total R-Value
					16.949
					1/0.059
					1÷Total U-

Reference Name: W.21.S2x6.16



Sketch of Construction Assembly

List of Construction ComponentsR-ValueCavity (R_c)R_c = 0.170

Calculation:

From EZFRAME

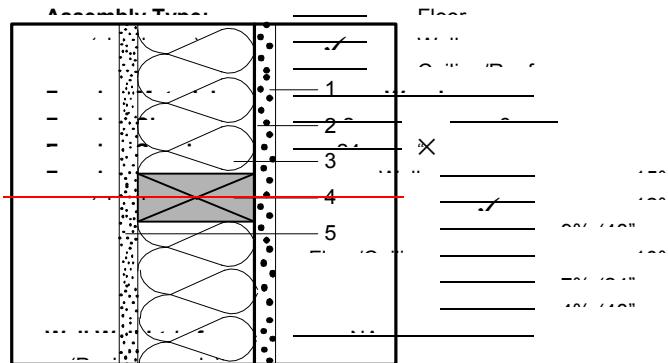
0.057

Total R

= 17.440

= Total R-Value

1/0.057

Reference Name: W.21.2x6.24

Sketch of Construction Assembly

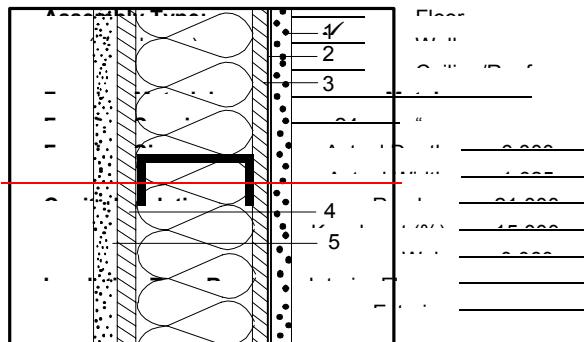
List of Construction ComponentsR-ValueCavity (R_c)R_c = 0.170Frame (R_f)R_f = 0.170

c

f

$$\begin{array}{l}
 \text{Framing Adjustment Calculation:} \\
 \frac{[(\frac{1}{122.540}) \times (\frac{1-12/100}{})] + [(\frac{1}{6.985}) \times (\frac{12/100}{})]}{1-(Fr.\% \div 100)} = \frac{1+R_f}{Fr.\% \div 100} = \frac{1/0.056}{1-\text{Total U-}} = \boxed{0.056} \\
 \boxed{\text{Total U-}} = \boxed{17.857} \\
 \boxed{\text{Total R-Value}}
 \end{array}$$

Reference Name: W.21.S2x6.24



Sketch of Construction Assembly

List of Construction Components

R-Value

Component	R-Value
Stud	0.170
Insulation 1	
Insulation 2	
Insulation 3	
Insulation 4	
Insulation 5	

Component	R-Value
Stud	0.170
Insulation 1	
Insulation 2	
Insulation 3	
Insulation 4	
Insulation 5	

Calculation:
From EZFRAME

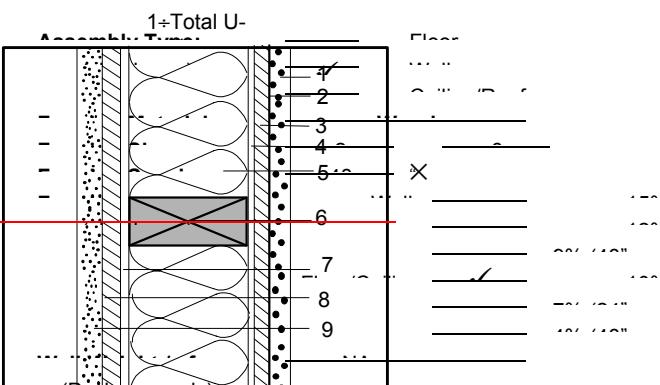
0.053

Total U-

= 18.720

= Total R-Value

Reference Name: WP.22.2x6.48



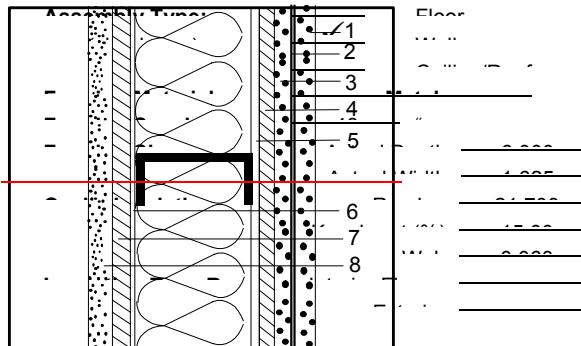
Sketch of Construction Assembly

~~List of Construction Components~~

~~R Value~~

Framing Adjustment Calculation:				0.049		
$\left[\frac{1}{1/25.736} \right]$	\times	$(\underline{1-9/100})$	$+$	$\left[\frac{(1/9.525)}{1+R_f} \right] \times (\underline{9/100})$	$=$	Total R
1+P.C.		1-(Fr.% ÷ 100)		1÷R _f	Fr.% ÷ 100	20.408
$\underline{\underline{1/0.049}}$						Total R-Value

Reference Name: WP.22.S2x6.48



~~Sketch of Construction Assembly~~

~~List of Construction Components~~

~~R Value~~

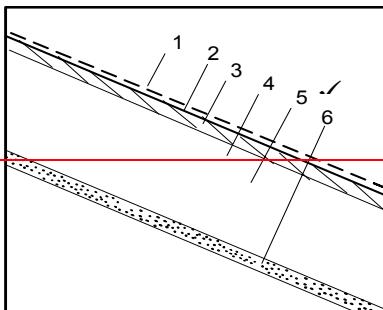
NAME	_____
GRADE	_____
TELEPHONE NUMBER	_____
ADDRESS	_____
CITY	_____
STATE	_____
ZIP CODE	_____
E-MAIL ADDRESS	_____
PARENT'S SIGNATURE	_____
PARENT'S SIGNATURE	_____

Calculation: From EZFRAME = **0.044**

~~Reference Name:~~ R.0.2x6.16

Total 11

<u>Assembly Total</u>	=	<u>22.83</u>
		<u>Floor</u>
		<u>Walls</u>
		<u>Doors</u>
		<u>Windows</u>
		<u>Roof</u>
		<u>Base</u>
		<u>Other</u>
		<u>Total</u>



Sketch of Construction Assembly

~~List of Construction Components~~

~~R Value~~

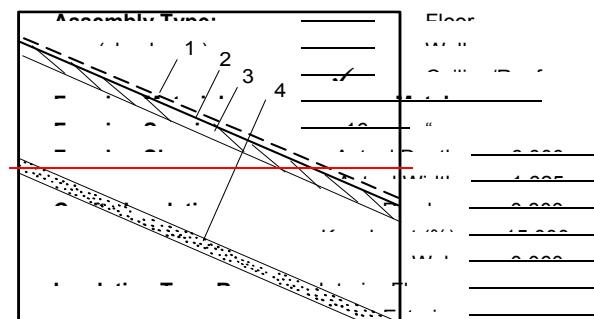
~~Gavity (R_c)~~

Frame (R_f)

$$[(\frac{1}{3.170}) \times (\frac{1-10/100}{1-(Fr.\% \div 100)}) + (\frac{1/7.815}{1+R_f}) \times (\frac{10/100}{Fr.\% \div 100})] = 1/0.297 = 3.367$$

Total R-Value

Reference Name: R.0.S2X6.16



Sketch of Construction Assembly

List of Construction Components

卷之三

~~R Value~~

0470

0.323

Total II

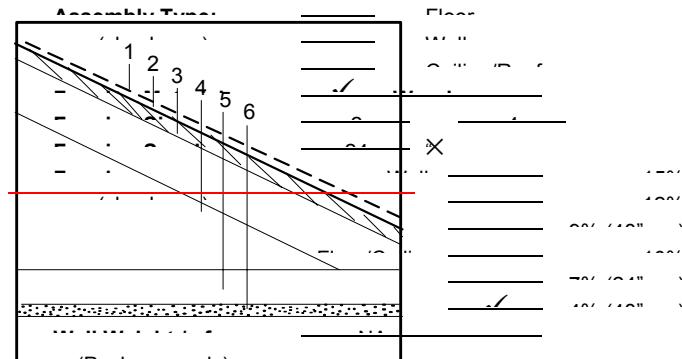
Calculation:
From EZFRAME

=

1/0.323

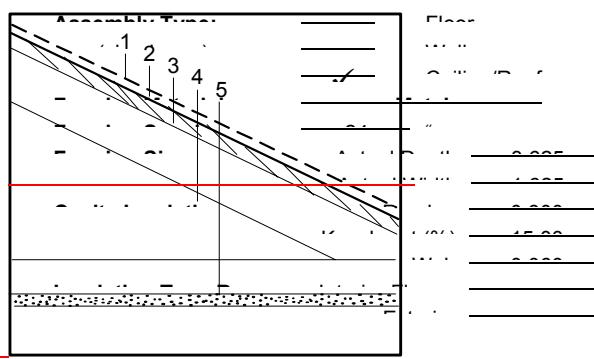
1÷Total U-

Reference Name: R.0.2x4.24



Sketch of Construction Assembly

Reference Name: R.0.S2X4.24



~~Sketch of Construction Assembly~~

List of Construction Components	R-Value
Brick Wall (8 inches)	2.170

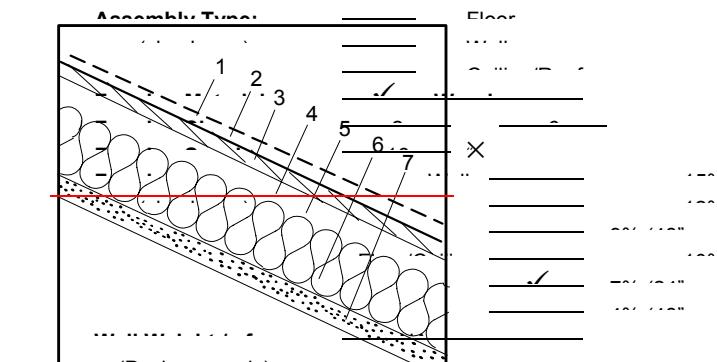
Calculation:
From EZFRAME

=

1/0.316

1=Total U-

Reference Name: R.11.2x6.16



Sketch of Construction Assembly

List of Construction Components	R-Value	
	Cavity (R _c)	Frame (R _f)
1=	0.170	0.170
2=		
3=		
4=		
5=		
6=		
7=		

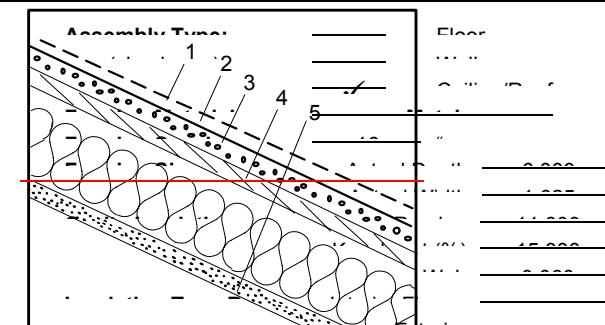
Framing Adjustment Calculation:

$$[(\frac{1}{14.150}) \times (\frac{1-10}{100})] + [(\frac{1}{7.815}) \times (\frac{10}{100})] = \boxed{0.076}$$

$$\frac{1+R_c}{1-(Fr.\% \div 100)} \quad \frac{1+R_f}{Fr.\% \div 100} = \frac{1/0.076}{13.157} = \frac{\text{Total U}}{\text{Total R-Value}}$$

1=Total U-

Reference Name: R.11.S2X6.16



Sketch of Construction Assembly

List of Construction Components

R-Value

Component A	R-Value

Component A	R-Value

0.071

Calculation:

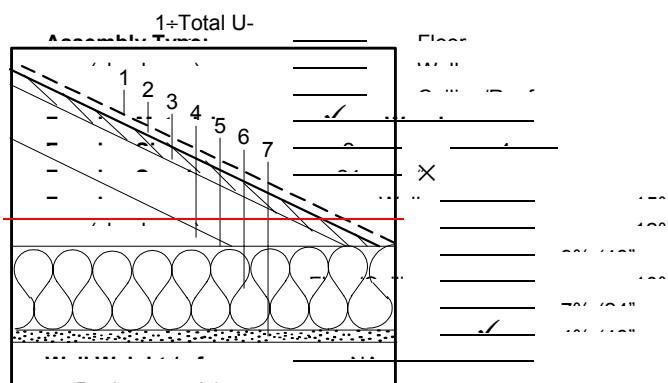
From EZFRAME

Total R-

14.060

Total R-Value

Reference Name: R.11.2x4.24



Sketch of Construction Assembly

List of Construction Components

R-Value

Component A	R-Value

Cavity (R _c)	Frame (R _f)

0.076

Framing Adjustment Calculation:

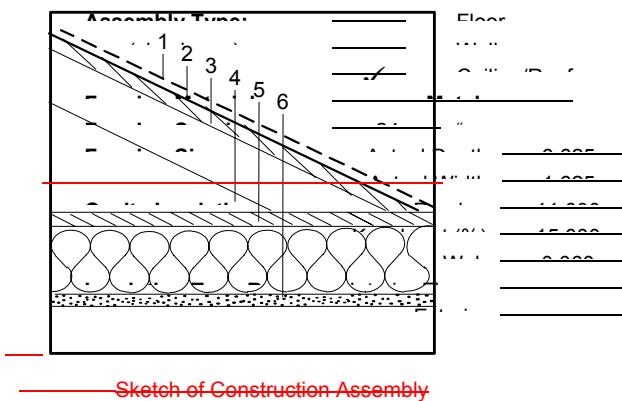
$$[(1/14.160) \times 1/R] + [(1/6.625) \times 1/R] - [(7/100) \times Fr.\% / 100] =$$

Total R-

13.157

(1-7/100)]
 c 1-(Fr.% ÷100) f
 1/0.076
 1÷Total U-

Reference Name: R.11.S2X4.24



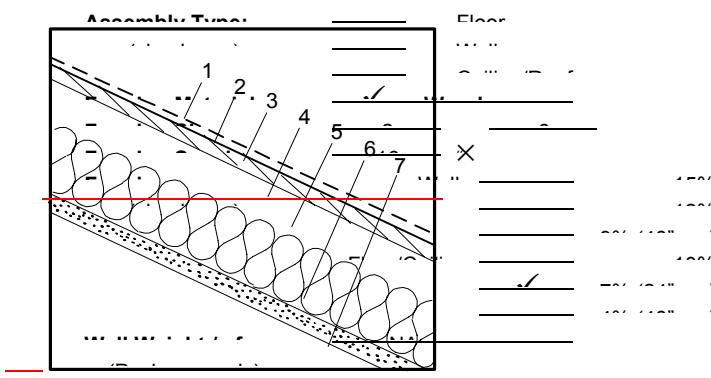
Sketch of Construction Assembly

List of Construction Components	R-Value
1	0.170
2	
3	
4	
5	
6	
7	
	0.069
	Total R-Value
	14.500
1/0.069	
1÷Total U-	

Calculation: From EZFRAME

Total R-Value

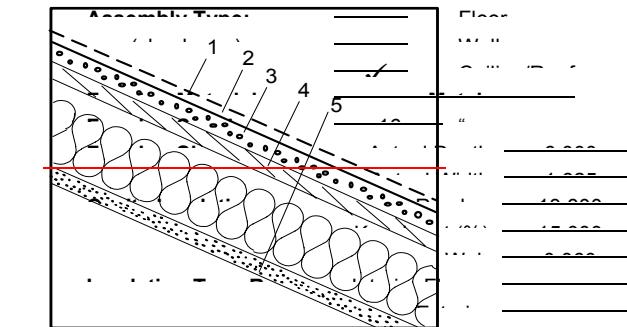
Reference Name: R.13.2x6.16



Sketch of Construction Assembly

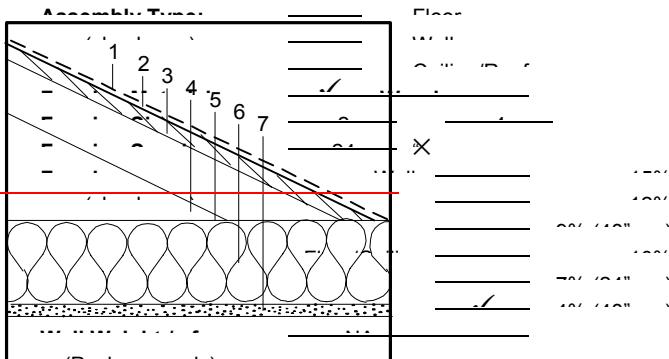
List of Construction Components	R-Value	
	Cavity (R _c)	Frame (R _f)
1. 16.150	16.150	16.150
2. 7.815	7.815	7.815
3. 10/100	0.100	0.100
4. 1-(Fr.% ÷ 100)	0.900	0.900
5. 1/R _c	0.069	0.069
6. 1/R _f	0.069	0.069
7. Fr.% ÷ 100	0.000	0.000
8. 1/0.069	14.493	14.493
9. Total R-Value	0.069	0.069
10. Total U-	Total U-Value	Total U-Value

Reference Name: R.13.S2X6.16



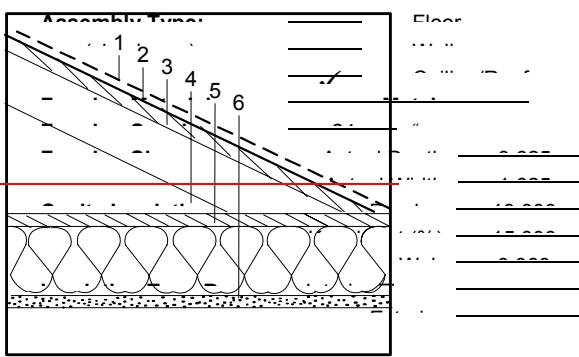
~~Sketch of Construction Assembly~~

Reference Name: R.13.2x4.24



~~Sketch of Construction Assembly~~

Reference Name: R.13.S2X4.24



~~Sketch of Construction Assembly~~

List of Construction Components R-Value

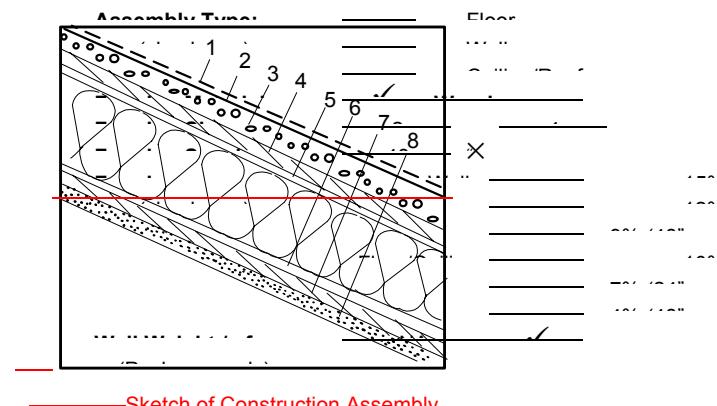
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12

Calculation:
From EZFRAME

=

1/0.066

Reference Name: RP.14.2x4.48



List of Construction Components

R-Value

Gavity (R_g)

Frame (R_f)

1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12

c f

0.058

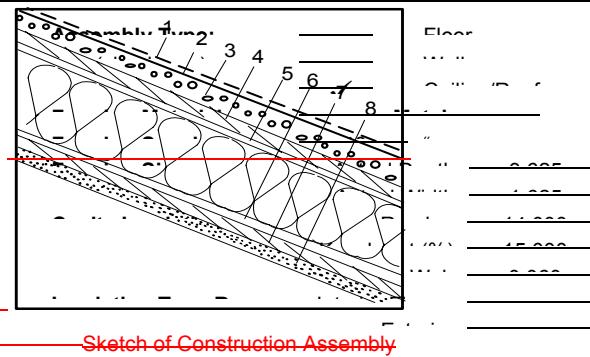
Total U

17.241

Total R-Value

$$\frac{[(\frac{1}{18.236}) \times (\frac{1-4}{100})]}{1+R_c} + \frac{[(\frac{1}{7.745}) \times (\frac{4}{100})]}{1+R_f} = \frac{1/0.058}{1-\text{Total U-}} = 0.058$$

Reference Name: RP.14.S2x4.48

List of Construction ComponentsR-Value

Component

R-Value

Component 1	0.170

Calculation:

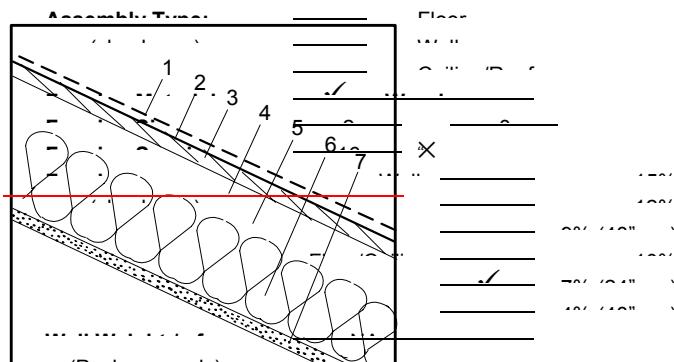
From EZFRAME

0.055**Total R-**

18.130

Total R-Value

1/0.055

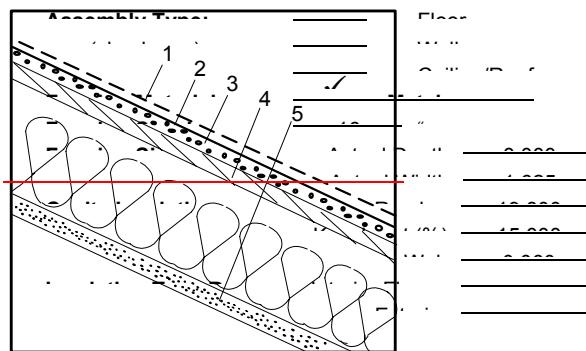
~~Reference Name: R.19.2x8.16~~~~Sketch of Construction Assembly~~List of Construction ComponentsR-ValueCavity (R_c)Frame (R_f)

Component	R-value	R-value
Exterior Insulation	0.170	0.170
Interior Insulation	0.170	0.170
Vapor Barrier	0.170	0.170
Structural Frame	0.170	0.170
Sheathing	0.170	0.170
Drywall	0.170	0.170
Interior Finish	0.170	0.170

Framing Adjustment Calculation:

$$\frac{[(1/22.130) \times (1-10/100)]}{1+R_c} + \frac{[(1/9.548) \times (10/100)]}{1+R_f} = \frac{Fr.\% \div 100}{1/0.051} = \frac{0.051}{1+Total\ U-} = \boxed{0.051}$$

Total R-Value
19.608

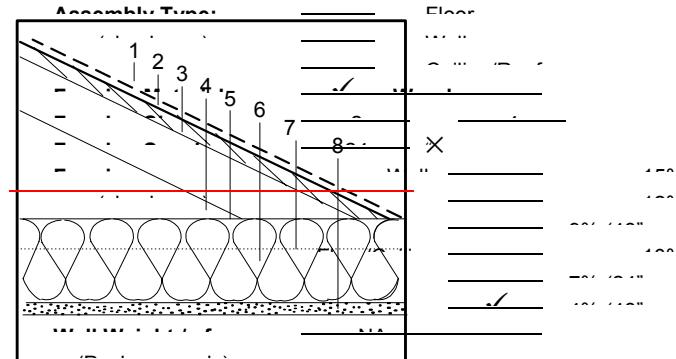
~~Reference Name: R.19.S2x8.16~~~~Sketch of Construction Assembly~~List of Construction ComponentsR-Value

Component	R-value
Exterior Insulation	0.170

Calculation:
From EZFRAME

=
1/0.051

Reference Name: R.19.2x4.24



Sketch of Construction Assembly

List of Construction Components

R-Value

Cavity (R_c)

Frame (R_f)

Component 1	0.170	0.170
Component 2	0.170	0.170
Component 3	0.170	0.170
Component 4	0.170	0.170
Component 5	0.170	0.170
Component 6	0.170	0.170
Component 7	0.170	0.170
Component 8	0.170	0.170

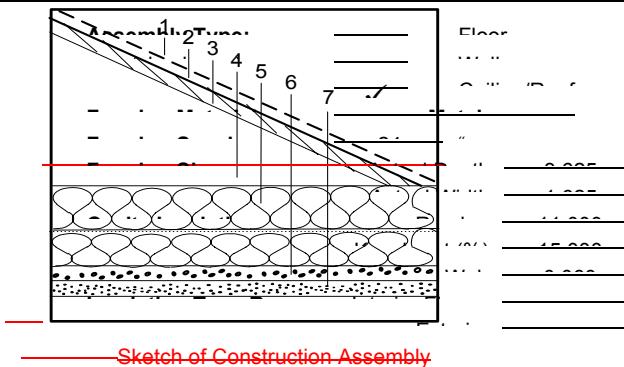
Framing Adjustment Calculation:

$$\left[\frac{1}{22.160} \times \frac{1-7/100}{1-(Fr.\% \div 100)} \right] + \left[\frac{1}{14.625} \times \frac{7/100}{Fr.\% \div 100} \right] = \boxed{0.047}$$

Total U- = 21.277

Total R-Value

Reference Name: R.19.S2x4.24

List of Construction ComponentsR-Value

G A V I T Y R = 0.170

F R A M E R = 0.170

Calculation:

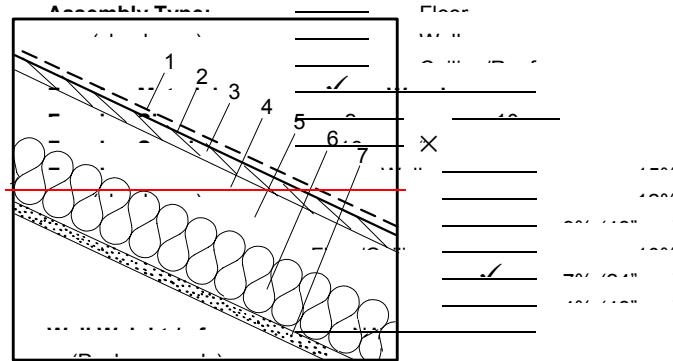
From EZFRAME

Total R

= 22.670

Total R-Value

1/0.044

Reference Name: R.22.2x10.16Sketch of Construction AssemblyList of Construction ComponentsR-Value

G A V I T Y R = 0.170

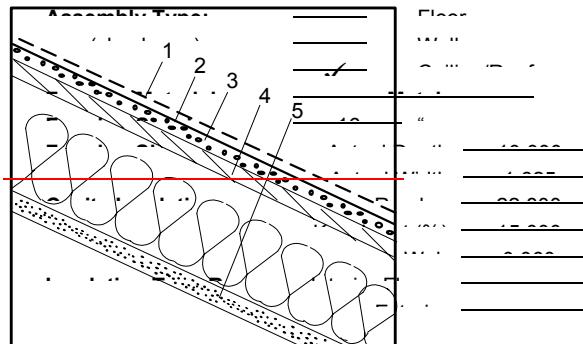
F R A M E R = 0.170

C f

Framing Adjustment Calculation:

$$\begin{array}{l} [(1/24.990) \times (1-10/100)] + [(1/12.148) \times (10/100)] = \\ 1-R_f \quad 1-(Fr.\% \div 100) \quad 1-R_f \quad Fr.\% \div 100 \\ \hline 1/0.044 = \\ 1 \div \text{Total U-} \end{array} \quad \boxed{0.044}$$

Total U:
22.727
Total R-Value

Reference Name: R.22.S2x10.16**Sketch of Construction Assembly****List of Construction Components****R-Value**

Component 1	0.170
Component 2	0.170
Component 3	0.170
Component 4	0.170
Component 5	0.170

0.170
0.170
0.170
0.170
0.170

Calculation:

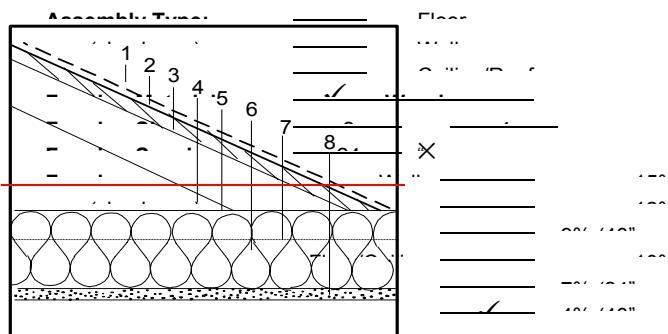
From EZFRAME

0.044**Total U:**

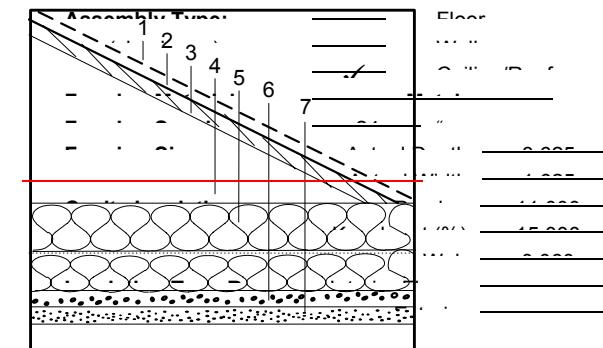
22.660

Total R-Value

1/0.044

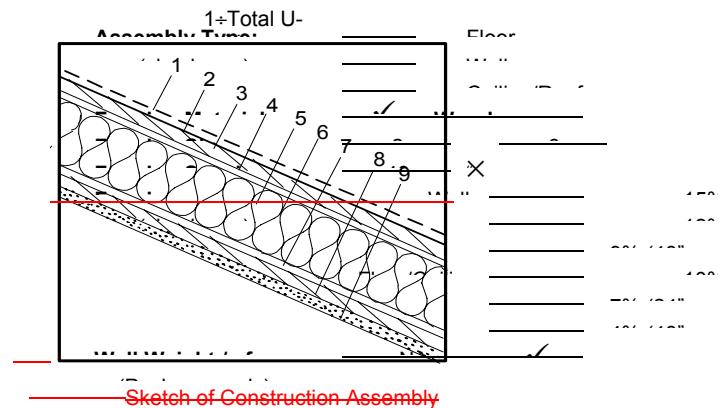
Reference Name: R.22.2x4.24**Sketch of Construction Assembly****List of Construction Components****R-Value**

Reference Name: R.22.S2x4.24



~~Sketch of Construction Assembly~~

Reference Name: RP.22.2x6.48



List of Construction Components

R-Value

Cavity (R_c)

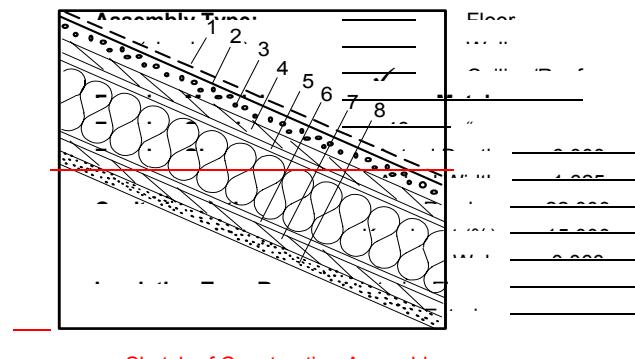
Frame (R_f)

Component 1	0.170	0.170
Component 2	0.170	0.170
Component 3	0.170	0.170
Component 4	0.170	0.170
Component 5	0.170	0.170
Component 6	0.170	0.170
Component 7	0.170	0.170
Component 8	0.170	0.170
Component 9	0.170	0.170

Framing Adjustment Calculation:

$$\left[\frac{1}{25.936} \times \frac{(1-4/100)}{1-(Fr.\% \div 100)} \right] + \left[\frac{1}{9.725} \times \frac{(4/100)}{1+R_f} \right] = \frac{0.041}{1/0.041} = \frac{0.041}{24.390} = \frac{\text{Total U}}{\text{Total R-Value}}$$

Reference Name: RP.22.S2x6.48

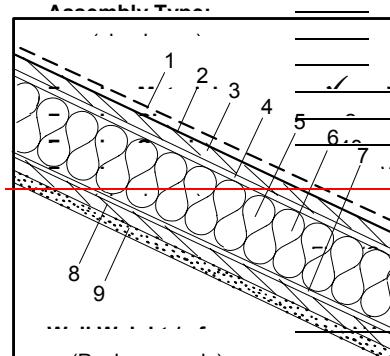


List of Construction Components

R-Value

U-value	0.170

Calculation:
From EZFRAME = **0.039**
Reference Name: RP.28.2x8.48 Total U: 25.460
1/0.039 =



Sketch of Construction Assembly

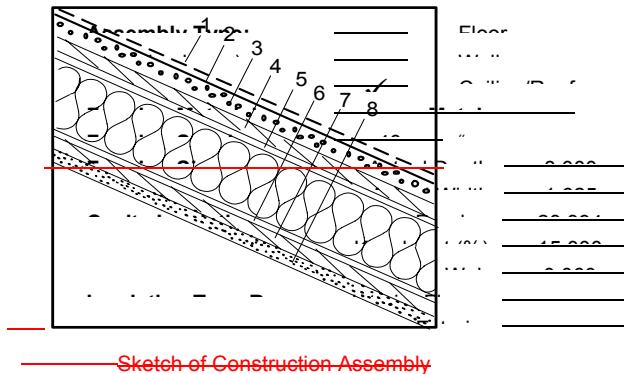
List of Construction ComponentsR-Value

Cavity (R _c)	Frame (R _f)
0.170	0.170

Framing Adjustment Calculation:

$$\frac{[(\frac{1}{32.674}) \times (\frac{1-4}{100})]}{1+R_c} + \frac{[(\frac{1}{11.458}) \times (\frac{4}{100})]}{1+R_f} = \frac{\text{Fr. \% } \div 100}{1/0.033} = \frac{0.033}{30.303} = \frac{\text{Total U}}{\text{Total R-Value}}$$

Reference Name: RP.28.S2x8.48



~~Sketch of Construction Assembly~~

List of Construction Components

~~List of Construction Components~~

~~R Value~~

~~Calculation:~~

From EZFRAME

0.031

Total 11

1/0.031

~~Reference Name:~~ R.30.2x12.16

1/0.03

This technical drawing illustrates an assembly of a spiral spring and a housing. The drawing includes several dimension lines and callouts:

- Callout 1: Dimension 1.000
- Callout 2: Dimension 0.500
- Callout 3: Dimension 0.500
- Callout 4: Dimension 0.500
- Callout 5: Dimension 0.500
- Callout 6: Dimension 0.500
- Callout 7: Dimension 0.500

The drawing also features a red horizontal line across the middle of the spring assembly.

~~Sketch of Construction Assembly~~

List of Construction Components

List of Construction Components

~~R-Value~~

NAME	DATE
_____ _____ _____ _____ _____	_____ _____ _____ _____ _____

Framing Adjustment Calculation:

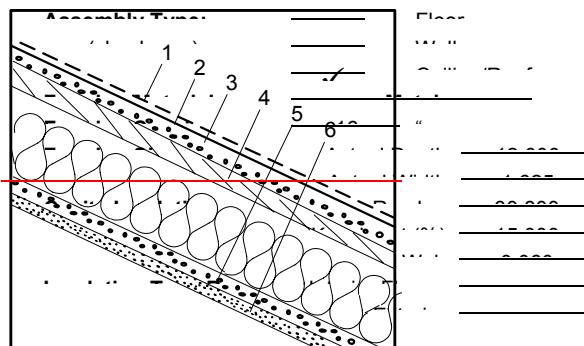
$$\begin{array}{lcl} \text{[(} \frac{1}{33.150} \text{)} \times \frac{(} 1-10/100 \text{)]}{1-R} + \text{[(} \frac{1}{13.508} \text{)} \times \frac{(} 10/100 \text{)]}{1-R} & = & \boxed{0.035} \\ \hline \frac{Fr.\%}{100} & & \text{Total } \text{II} \\ \hline & & 28.571 \end{array}$$

c

f

1/0.035

1=Total U-

Reference Name: R.30.S2x12.16

Sketch of Construction Assembly

List of Construction ComponentsR-Value

G A V I T Y A R E A

0.170

Calculation:

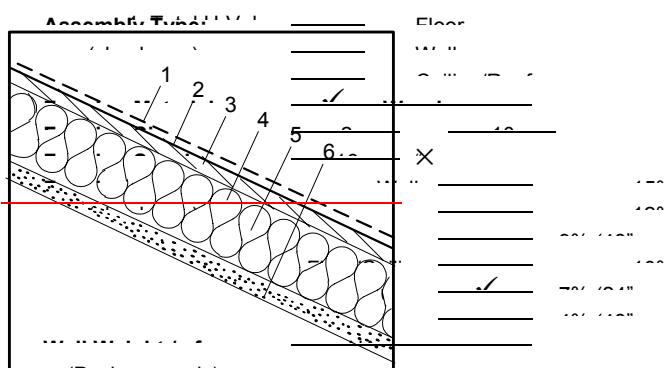
From EZFRAME

0.032**Total R**

31.64

Reference Name: R.30.2x10.16

Total R-Value



Sketch of Construction Assembly

List of Construction ComponentsR-Value

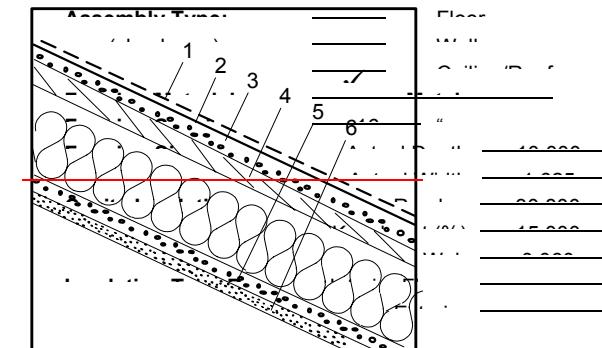
G A V I T Y A R E A

0.170

Frame (R_f)

$\frac{[(1/32.370) \times (1-10/100)]}{1+R_c} + \frac{[(1/11.528) \times (10/100)]}{1-(Fr.\% \div 100)} = \frac{1/R_c}{Fr.\% \div 100}$	$\frac{1}{0.036} =$	0.036 Total U: 27.778 Total R-Value $1 \div \text{Total U}$
---	---------------------	--

Reference Name: R.30.S2x10.16



Sketch of Construction Assembly

List of Construction Components

R-Value

~~0.170~~

0.034

Calculation:
From EZFRAME

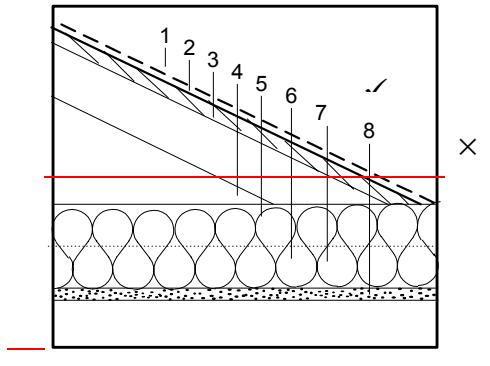
Total U:

29.220

Total R-Value

Reference Name: R.30.2x4.24

$1 \div \text{Total U}$



~~Sketch of Construction Assembly~~

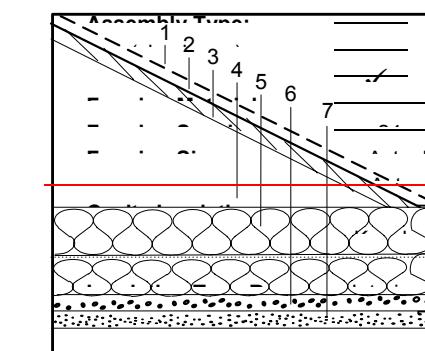
~~List of Construction Components~~

© 2012, 2013, 2014

~~R-Value~~

Framing Adjustment Calculation:				0.031
$\left[\frac{\left(\frac{1}{33.160} \right)}{1+R_c} \times \left(\frac{1-7}{100} \right) \right]$	+	$\left[\frac{\left(\frac{1}{25.625} \right)}{1+R_f} \times \left(\frac{7}{100} \right) \right]$	=	Total II
$\frac{1}{33.160}$	$\frac{1-7}{100}$	$\frac{1}{25.625}$	$\frac{7}{100}$	32.258
$\frac{1}{1+R_c}$	$1-(Fr.\% \div 100)$	$\frac{1}{1+R_f}$	$Fr.\% \div 100$	Total R-Value
$\frac{1}{0.031}$				100.000

Reference Name: B-30 S2x4 24



Sketch of Construction Assembly

List of Construction Components

CHAP. 6 - APPENDIX

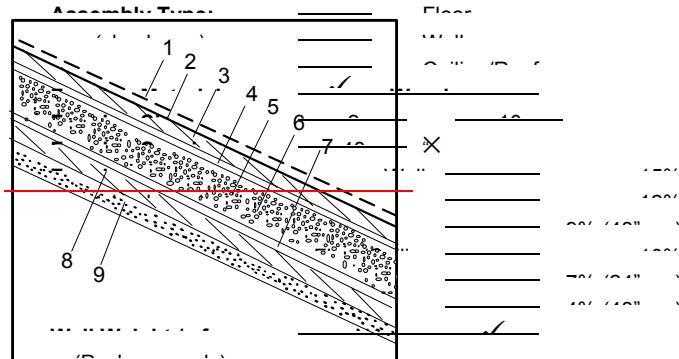
~~R-Value~~

0170

Calculation:
From EZFRAME

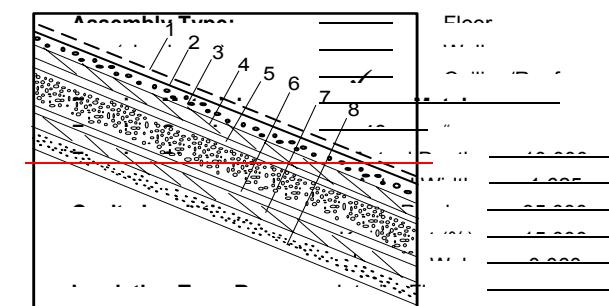
$$\frac{1/0.030}{\text{A T A I I}} =$$

Reference Name: RP.35.2x10.48



~~Sketch of Construction Assembly~~

~~Reference Name:~~ RP.35.S2x10.48



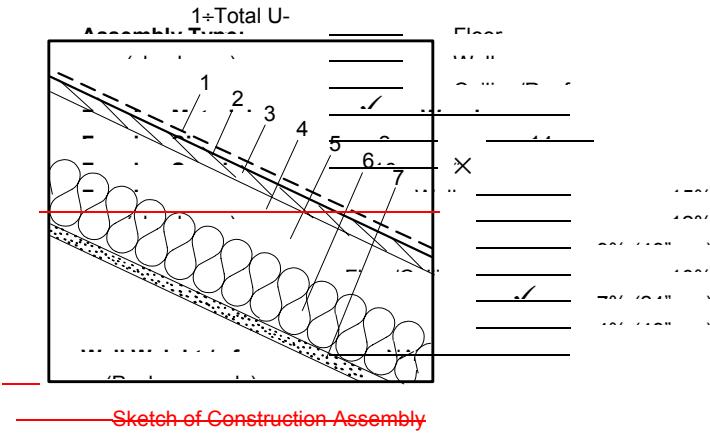
Sketch of Construction Assembly

List of Construction Components	R Value
Wood joists	1.5

Calculation:
From EZFRAME

=

Reference Name: R.38.2x14.16



List of Construction Components

R-Value

Cavity (R _c)	Frame (R _f)
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170
0.170	0.170

Framing Adjustment Calculation:

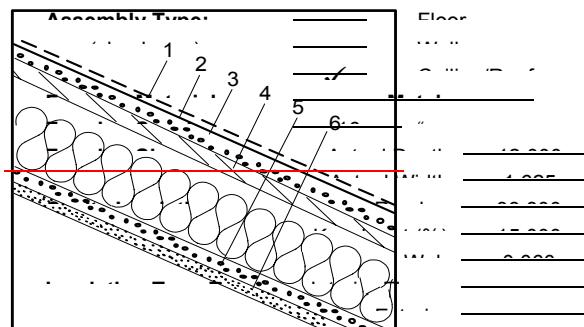
$$\begin{aligned} & [(\frac{1}{41.130}) \times (\frac{1-10}{100})] + [(\frac{1}{15.488}) \times (\frac{10}{100})] = 0.028 \\ & \frac{1 \div R_c}{1-(Fr.\% \div 100)} \quad \frac{1 \div R_f}{Fr.\% \div 100} \\ & \frac{1}{0.028} = \frac{35.714}{Total R-Value} \end{aligned}$$

Reference Name: R.38.S2x14.16

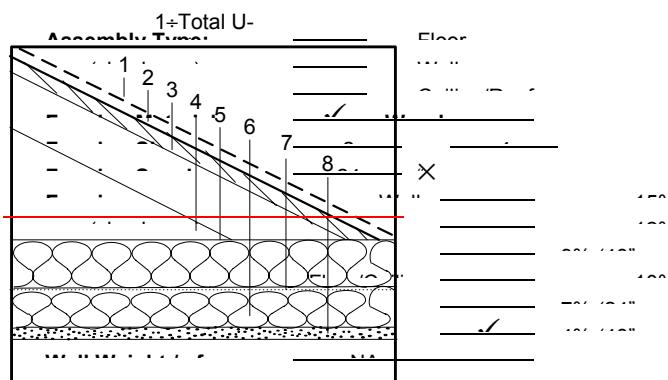
~~Framing Adjustment Calculation:~~

$$\begin{array}{l} [(\frac{1}{40.370}) \times (\frac{1-10/100}{100})] + [(\frac{1}{13.508}) \times (\frac{10/100}{100})] = \boxed{0.030} \\ 1 \div R_c \quad 1 - (Fr.\% \div 100) \quad 1 \div R_f \quad Fr.\% \div 100 \\ \hline 1/0.030 = \boxed{33.333} \\ 1 \div \text{Total U-} \end{array}$$

**Total U-
Total R-Value**

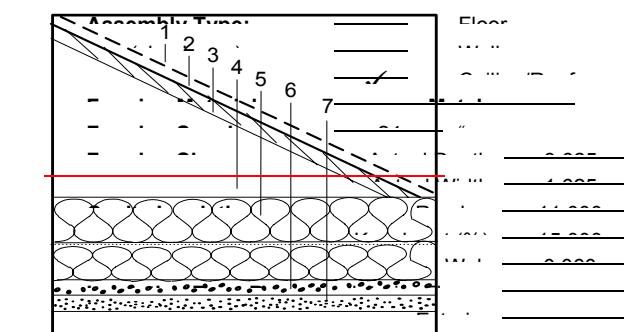
Reference Name: R.38.S2x12.16**Sketch of Construction Assembly****List of Construction Components****R-Value**

Component 1	0.170
Component 2	
Component 3	
Component 4	
Component 5	
Component 6	

0.170**Total U-****33.38****0.030****Total R-Value****Calculation:
From EZFRAME****Reference Name:** R.38.2x4.24**Sketch of Construction Assembly**

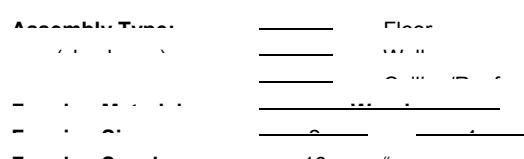
List of Construction Components		R-Value	
		Gavity (Rc)	Frame (Rf)
Ceiling	1/41.160	0.170	0.170
Walls	1/33.625	0.170	0.170
Floor	1/41.160	0.170	0.170
Total		0.025	0.025
		Total R-Value	40.000

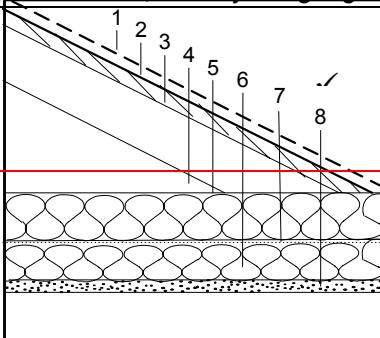
Reference Name: R.38.S2x4.24



Sketch of Construction Assembly

~~Reference Name: R-49-2x4-16~~





Sketch of Construction Assembly

List of Construction ComponentsR-Value

<u>Cavity (R_c)</u>	<u>Frame (R_f)</u>

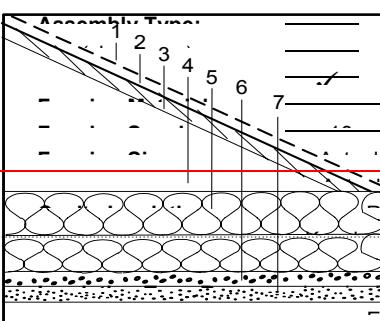
Framing Adjustment Calculation:

$$\frac{[(\underline{1/52.160}) \times (\underline{1-10/100})]}{1+R_c} + \frac{[(\underline{1/44.625}) \times (\underline{10/100})]}{1-(Fr.\% \div 100)} = \frac{1/R}{1/R_f - Fr.\% \div 100}$$

$$= \frac{1/0.019}{52.632} = \frac{\text{Total U-}}{\text{Total R-Value}}$$

0.019**Total U-**

52.632

Reference Name: R.49.S2x4.16

Sketch of Construction Assembly

List of Construction ComponentsR-Value

<u>Cavity (R_c)</u>	<u>Frame (R_f)</u>

0.019**Total U-**

53.02

Calculation:

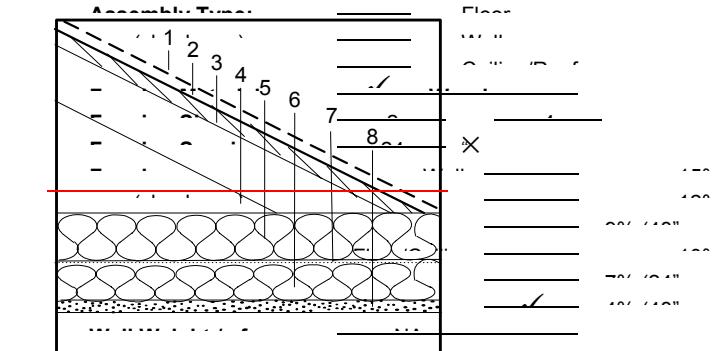
From EZFRAME

=

1/0.019

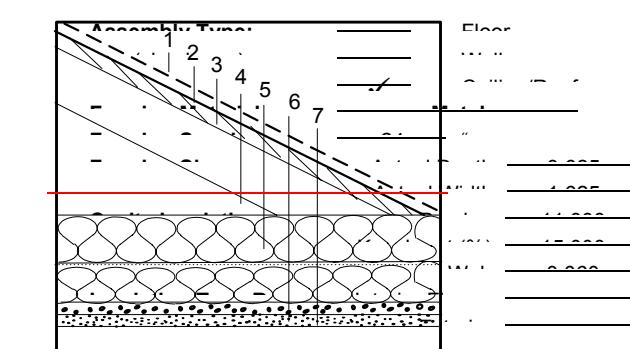
1÷Total U-

Reference Name: R.49.2x4.24



Sketch of Construction Assembly

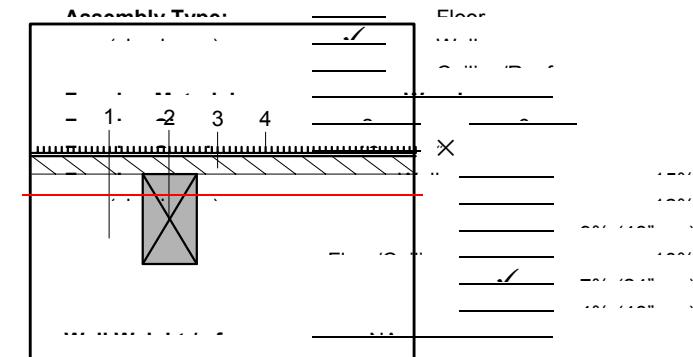
Reference Name: B-49 S3x1.34



Sketch of Construction Assembly

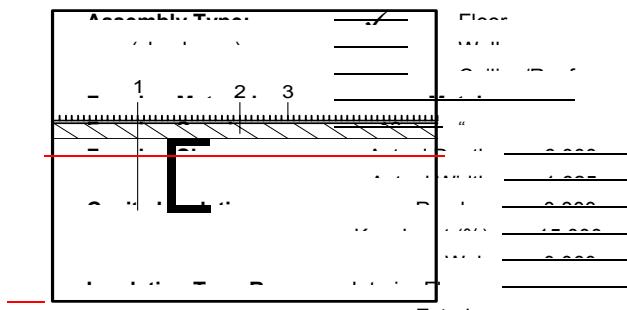
List of Construction Components

Reference Name: FC.0.2x6.16



Sketch of Construction Assembly

Reference Name: FC.0.S2x6.16



Sketch of Construction Assembly

List of Construction Components

~~AMBIENT LIGHT~~

~~0.170~~

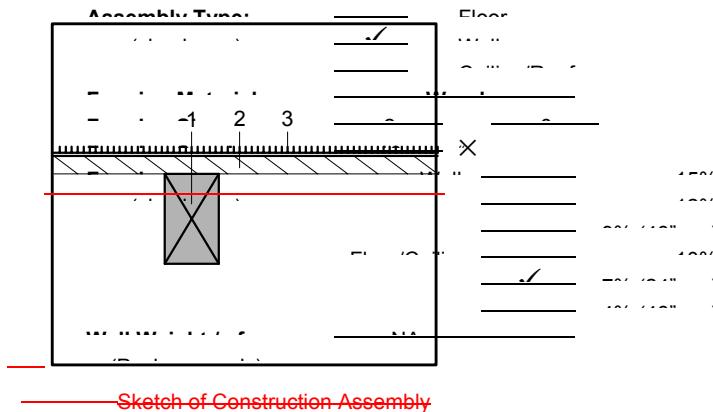
Calculation:

From EZFRAME

=

1/0.094

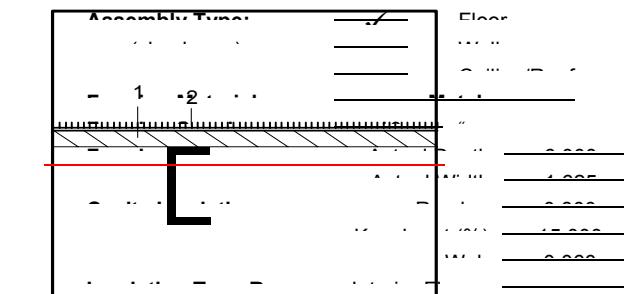
1÷Total U-

Reference Name: FX.0.2x6.16List of Construction ComponentsR-Value

Cavity (R _c)	Frame (R _f)

Framing Adjustment Calculation:

$$\begin{aligned} & \left[\frac{1}{3.950} \times \frac{1-10/100}{1-(Fr.\% \div 100)} \right] + \left[\frac{1}{9.395} \times \frac{10/100}{Fr.\% \div 100} \right] = \boxed{0.238} \\ & \frac{1}{0.238} = \frac{\text{Total U}}{4.202} \\ & 1 \div \text{Total U} = \text{Total R-Value} \end{aligned}$$

Reference Name: FX.0.S2x6.16List of Construction ComponentsR-Value

0.470

0.470

Calculation:

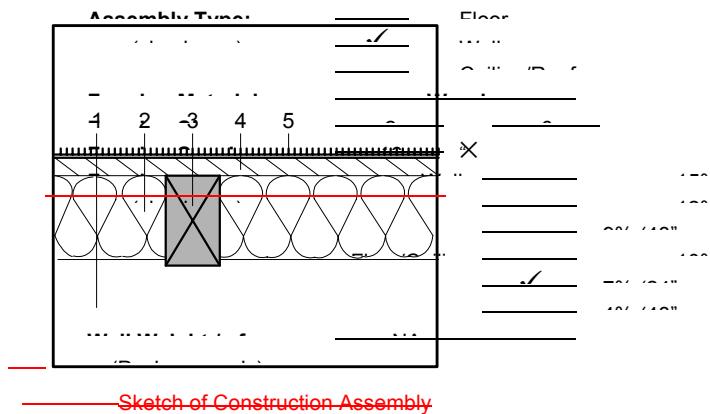
From EZFRAME

=

1/0.253

1÷Total U-

Reference Name: FC.11.2x6.16



List of Construction Components

R-Value

Gavity (R_g)

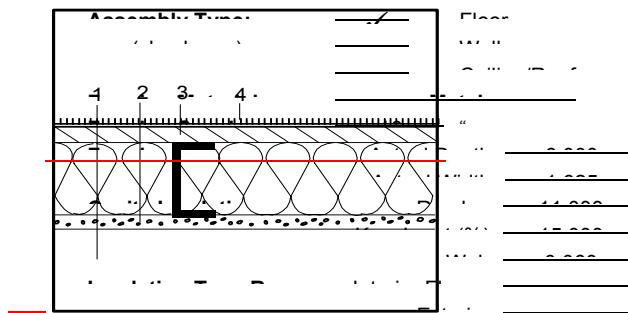
Frame (R_f)

Component	R_g	R_f
Exterior Wall		
Insulation		
Vapor Barrier		
Interior Drywall		
Column		

Framing Adjustment Calculation:

$$\begin{aligned} & \left[\frac{1}{20.950} \times \frac{(1-10/100)}{1-(Fr.\% \div 100)} \right] + \left[\frac{1}{15.395} \times \frac{(10/100)}{1+R_f} \right] = \boxed{0.049} \\ & \frac{1}{0.049} = \frac{\text{Total U}}{20.408} \\ & \text{Total R-Value} \end{aligned}$$

Reference Name: FC.11.S2x6.16



List of Construction Components

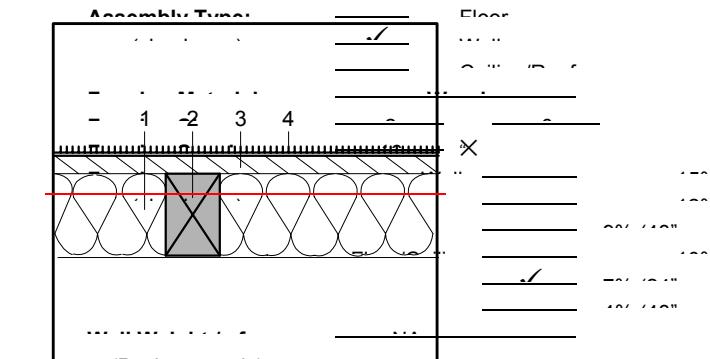
R-Value

~~0.170~~~~0.170~~

Calculation:
From EZFRAME

$$\frac{1/0.048}{1-\text{Total U-}} =$$

Reference Name: FX.11.2x6.16



Sketch of Construction Assembly

~~List of Construction Components~~

~~R Value~~

Cavity (R_c)	Frame (R_f)
0.170	0.170

Framing Adjustment Calculation:				
$\left[\left(\frac{1}{1/14.950} \right) \times \left(\frac{1-10/100}{1-Fr.\% \div 100} \right) \right] + \left[\left(\frac{1/9.395}{1 \div R_f} \right) \times \left(\frac{10/100}{Fr.\% \div 100} \right) \right]$	=		0.071	
$\frac{1 \div R_c}{c}$	$\frac{1-Fr.\% \div 100}{1-Fr.\% \div 100}$		Total II	
$\frac{1 \div R_f}{f}$	$\frac{Fr.\% \div 100}{Fr.\% \div 100}$		$\frac{14.085}{14.085}$	
$\frac{1/0.071}{1 \div Total\ U-}$			Total R-Value	

Reference Name: FX.11.S2x6.16



Sketch of Construction Assembly

List of Construction Components

~~R-Value~~

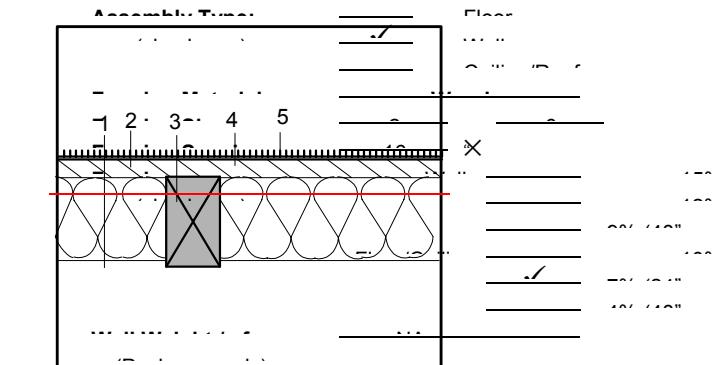
© 2010 Cengage Learning

0470

~~Calculation:~~ From EZFRAME

1/0.071

Reference Name: EC.13.2x6.16



Sketch of Construction Assembly

List of Construction Components

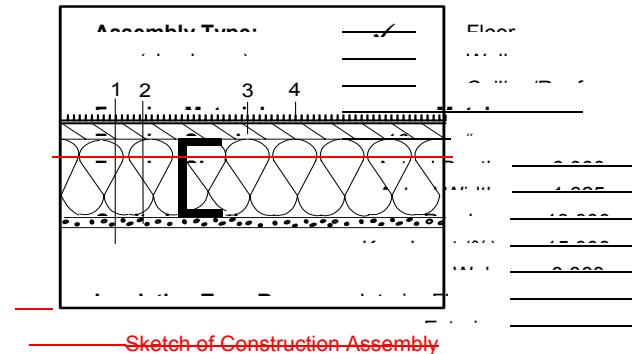
~~R Value~~

ANSWER SHEET

Gavity (P_c)	Frame (P_f)
<hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>	<hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>

Framing Adjustment Calculation:				0.046
$\left[\left(\frac{1}{22.950} \right) \times \left(\frac{1-10}{100} \right) \right]$	$+ \left[\left(\frac{1}{15.395} \right) \times \left(\frac{10}{100} \right) \right]$	=	Total U-	Total R-Value
$\frac{1-R_c}{c}$	$1-(Fr.\% \div 100)$	$\frac{1-R_f}{f}$	$\frac{Fr.\% \div 100}{1/0.046}$	$\frac{21.740}{1/0.046}$
				Total R-Value

Reference Name: FC.13.S2x6.16

List of Construction ComponentsR-Value

G - G - G - G - G

0.170

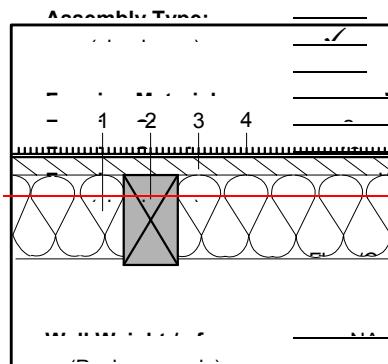
0.043Calculation:

From EZFRAME

Total R

= 23.340

1/0.043 =

Total R-ValueReference Name: UX.13.2x6.16List of Construction ComponentsR-Value

G - G - G - G - G

Gavity (R_G)**Frame (R_F)**

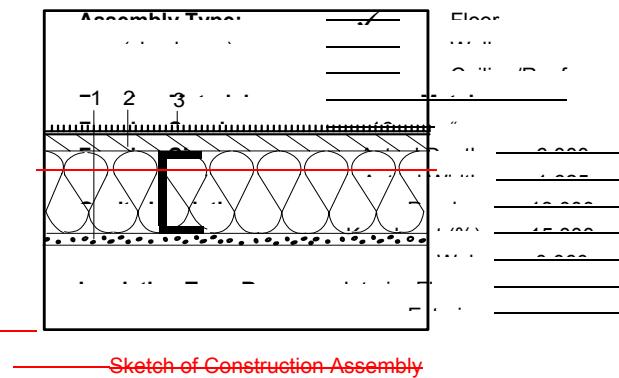
c**f**

Framing Adjustment Calculation:

$$\begin{array}{l} \frac{[(\frac{1}{16.950}) \times (\frac{1-10}{100})] + [(\frac{1}{9.395}) \times (\frac{10}{100})]}{1+R_c \quad 1-(Fr.\% \div 100) \quad 1+R_f \quad Fr.\% \div 100} = \boxed{0.064} \\ \hline \end{array}$$

$$\begin{array}{l} \frac{1/0.064}{1+Total U-} = \boxed{15.625} \\ \hline \end{array}$$

Total R-Value

Reference Name: FX.13.S2x6.16**List of Construction Components****R-Value**

Component 1	
Component 2	
Component 3	
Component 4	
Component 5	

Component 1	
Component 2	
Component 3	
Component 4	
Component 5	

Calculation:

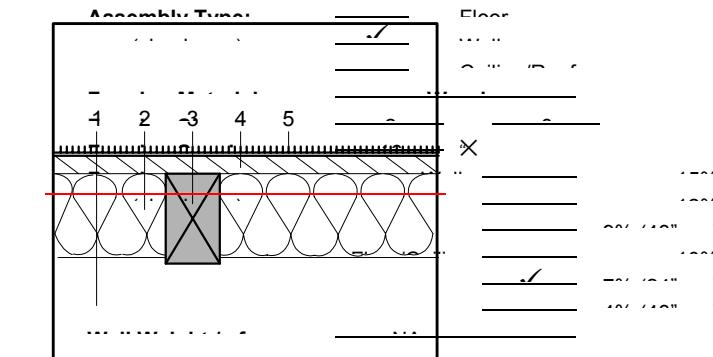
From EZFRAME

$$\begin{array}{l} \frac{1/0.058}{1+Total U-} = \boxed{0.058} \\ \hline \end{array}$$

$$\begin{array}{l} \frac{1/0.058}{1+Total U-} = \boxed{17.340} \\ \hline \end{array}$$

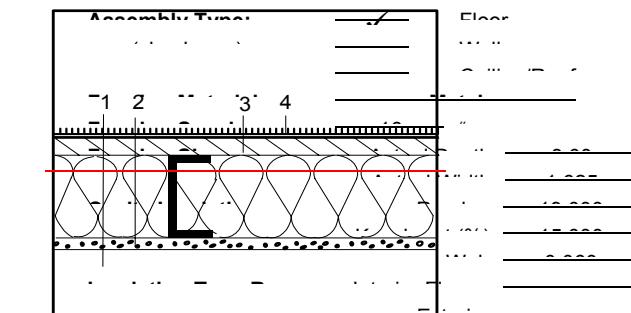
Total R-Value

Reference Name: FC.19.2x8.16



Sketch of Construction Assembly

~~Reference Name:~~ FC.19.S2x8.16



~~Sketch of Construction Assembly~~

List of Construction Components

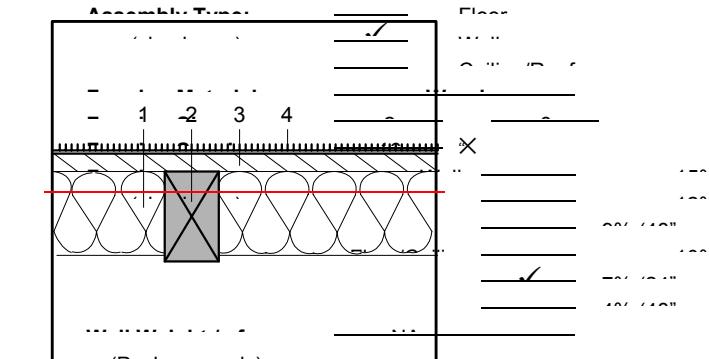
© 2010 Cengage Learning

0430

~~Calculation:~~ From EZFRAME

1/0.035

Reference Name: ~~FX.19.2x8.16~~



Sketch of Construction Assembly

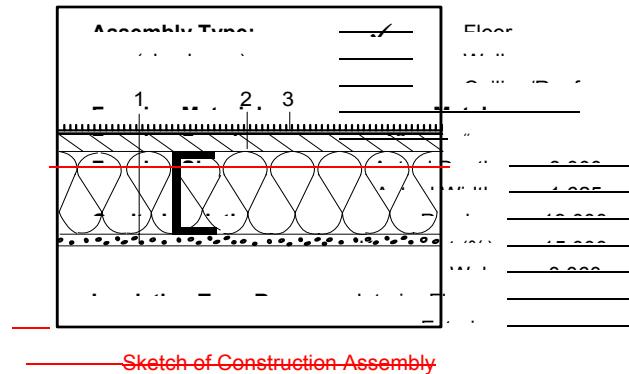
List of Construction Components

~~R Value~~

ANSWER SHEET

Framing Adjustment Calculation:				0.049
$\left[\left(\frac{1}{22.950} \right) \times \left(\frac{1-10/100}{1-(Fr.\%+100)} \right) + \left(\frac{1}{11.128} \times \frac{10/100}{Fr.\%+100} \right) \right]$				=
$\frac{1+R_c}{1-(Fr.\%+100)}$	$\frac{1+R_f}{Fr.\%+100}$			Total U
1/0.049				20.408
				Total R-Value

Reference Name: FX.19.S2x8.16

List of Construction ComponentsR-Value

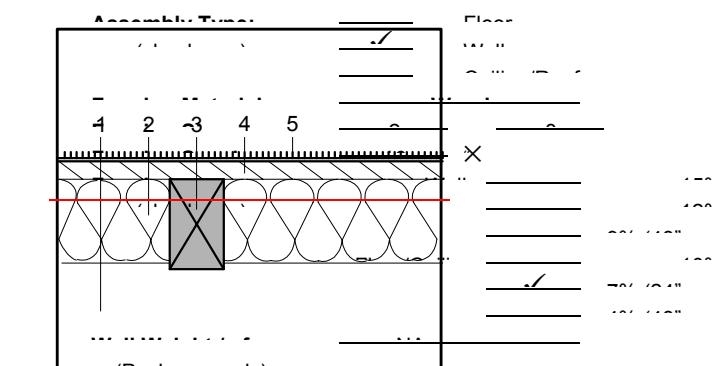
Component 1	_____
Component 2	_____
Component 3	_____
Component 4	_____
Component 5	_____
Component 6	_____
Component 7	_____
Component 8	_____
Component 9	_____
Component 10	_____
Component 11	_____
Component 12	_____
Component 13	_____
Component 14	_____
Component 15	_____
Component 16	_____
Component 17	_____
Component 18	_____
Component 19	_____
Component 20	_____

Component 1	_____
Component 2	_____
Component 3	_____
Component 4	_____
Component 5	_____
Component 6	_____
Component 7	_____
Component 8	_____
Component 9	_____
Component 10	_____
Component 11	_____
Component 12	_____
Component 13	_____
Component 14	_____
Component 15	_____
Component 16	_____
Component 17	_____
Component 18	_____
Component 19	_____
Component 20	_____

Calculation:

From EZFRAME

$$\frac{1}{0.048} = 20.950$$

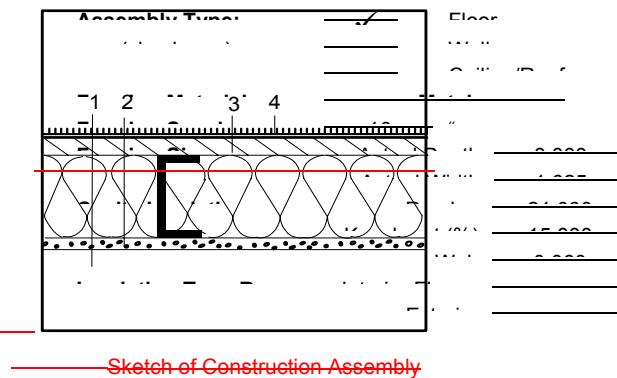
0.048**Total R-Value**Reference Name: EC.21.2x8.16List of Construction ComponentsR-Value

Component 1	_____
Component 2	_____
Component 3	_____
Component 4	_____
Component 5	_____
Component 6	_____
Component 7	_____
Component 8	_____
Component 9	_____
Component 10	_____
Component 11	_____
Component 12	_____
Component 13	_____
Component 14	_____
Component 15	_____
Component 16	_____
Component 17	_____
Component 18	_____
Component 19	_____
Component 20	_____

Cavity (R _c)	_____
Frame (R _f)	_____
Component 1	_____
Component 2	_____
Component 3	_____
Component 4	_____
Component 5	_____
Component 6	_____
Component 7	_____
Component 8	_____
Component 9	_____
Component 10	_____
Component 11	_____
Component 12	_____
Component 13	_____
Component 14	_____
Component 15	_____
Component 16	_____
Component 17	_____
Component 18	_____
Component 19	_____
Component 20	_____

Framing Adjustment Calculation:

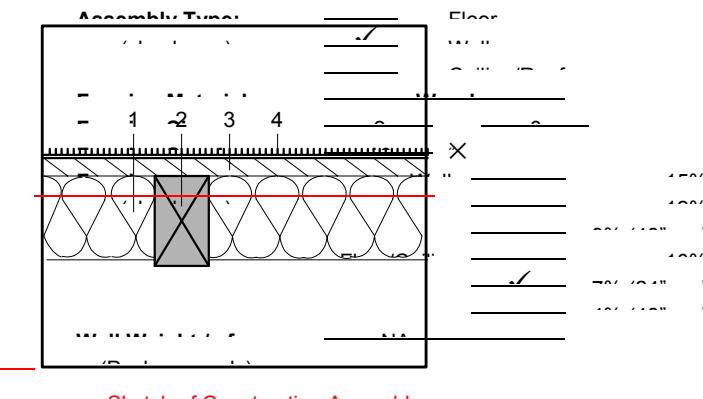
$$\begin{array}{l} [(\frac{1}{30.950}) \times (\frac{1-10}{100})] + [(\frac{1}{17.128}) \times (\frac{10}{100})] = \boxed{0.032} \\ 1 \div R_c \qquad \qquad \qquad 1-(Fr.\% \div 100) \qquad \qquad \qquad \frac{1 \div R_f}{Fr.\% \div 100} \\ \hline 1/0.032 = \boxed{\text{Total U}} \\ 1 \div \text{Total U} = \boxed{31.250} \\ \hline \text{Total R-Value} \end{array}$$

Reference Name: FC.21.S2x8.16**List of Construction Components****R-Value**

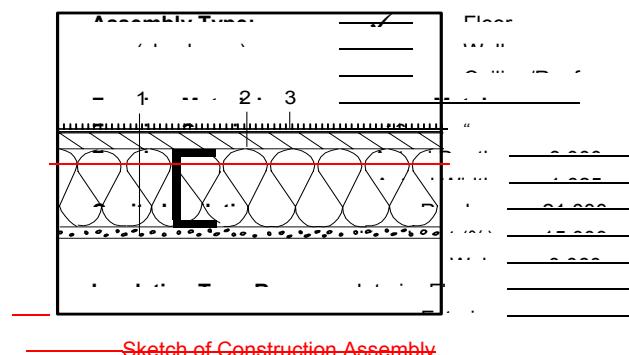
Component	R-Value
Header Joist	0.170
Plate	
Insulation	
Studs	
Foundation	
Soil	

0.034**Calculation:**

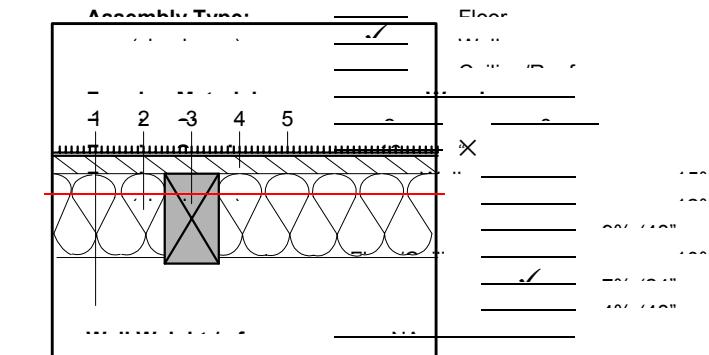
From EZFRAME

Total U**29.080****1/0.034****Total R-Value****Reference Name:** EX.21.2x8.16**List of Construction Components****R-Value**

~~Reference Name:~~ FX.21.S2x8.16



Reference Name: FC.30.2x10.16



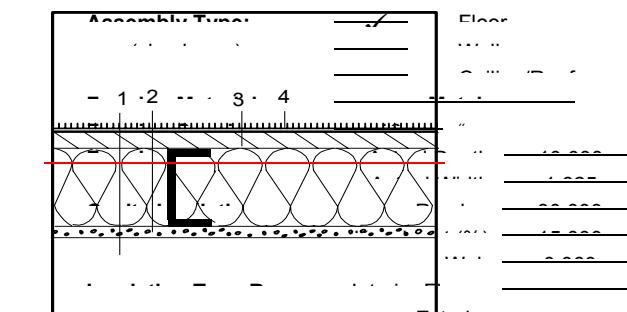
Sketch of Construction Assembly

List of Construction Components

~~R Value~~

Framing Adjustment Calculation:				
$\left[\left(\frac{1}{39.950} \right) \times \left(\frac{1-10}{100} \right) \right]$	$+ \left[\left(\frac{1}{19.028} \right) \times \left(\frac{10}{100} \right) \right] =$		0.028	
$\frac{1}{1-R}$ c	$\frac{1-(Fr.\% \div 100)}{f}$		Total R	
<hr style="border: 0; border-top: 1px solid black; margin-bottom: 5px;"/>				<hr style="border: 0; border-top: 1px solid black; margin-bottom: 5px;"/>
$= \frac{1/0.028}{1 \div \text{Total U-}}$				$= \frac{35.714}{\text{Total R-Value}}$

Reference Name: FC.30.S2x10.16



~~Sketch of Construction Assembly~~

List of Construction Components

~~R Value~~

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Calculation:

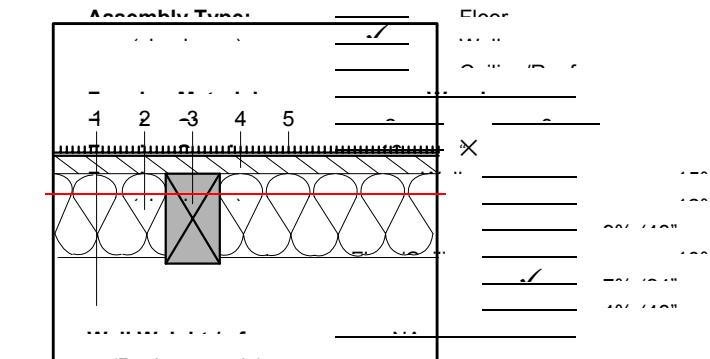
From EZFRAME

=

1/0.026

1÷Total U-

Reference Name: FX.30.2x10.16



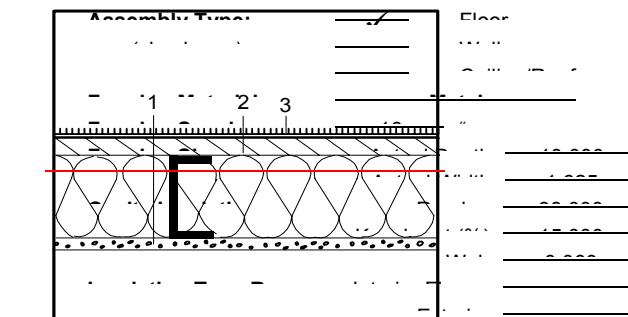
Sketch of Construction Assembly

~~List of Construction Components~~

~~R Value~~

Framing Adjustment Calculation:				0.034
$\left[\left(\frac{1}{33.950} \right) \times \left(\frac{1-10}{100} \right) \right]$	+	$\left[\left(\frac{1}{13.108} \right) \times \left(\frac{10}{100} \right) \right]$	=	Total R
$\frac{1}{1+R}$ c	1-(Fr.% ÷ 100)	$\frac{1}{1+R}$ f	$\frac{Fr.\% \div 100}{1+R}$	Total R Value
<hr/>				29.412
<hr/>				1/0.034
<hr/>				1÷Total U-

Reference Name: FX.30.S2x10.16



~~Sketch of Construction Assembly~~

List of Construction Components

R-Value

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0.470

A 49A

~~Calculation:~~

2

Computer Modeling of Framed Assemblies 170.031

1÷Total U-

~~EZFrame~~ can be purchased by ordering the following:

~~Publication No.: P400-94-002R~~

~~Cost: \$14.00~~

Address: California Energy Commission
Publications, MS-13
P.O. Box 944295
Sacramento, CA 94244-2950

Or Download Free *EZFrame* Computer Modeling of Framed Assemblies Program at the following ftp site:

~~ftp://energy.ca.gov/pub/efftech/~~

Table B-8A: Fan Motor Efficiencies (< 1 HP)

~~NOTE: For default drive efficiencies, See Section 4.2.2~~

~~*NEMA—Proposed standard using test procedures.~~

~~Minimum NEMA efficiency per test IEEE 112b Rating Method.~~

TABLE B-8B: Fan Motor Efficiencies (1 HP and over)

Number of Poles	Open Motors				Enclosed Motors			
	2	4	6	8	2	4	6	8
Synchronous Speed	3600	1800	1200	900	3600	1800	1200	900
<u>Motor Horsepower</u>								
1	—	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1.5	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
5	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
7.5	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15	89.5	91.0	92.0	89.5	90.2	91.0	90.2	88.5
20	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
25	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
30	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
40	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0
50	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
60	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
75	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
100	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0
125	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
200	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
250	94.5	95.0	95.4	94.5	95.4	95.0	95.0	94.5
300	95.0	95.4	95.4	—	95.4	95.4	95.0	—
350	95.0	95.4	95.4	—	95.4	95.4	95.0	—
400	95.4	95.4	—	—	95.4	95.4	—	—
450	95.8	95.8	—	—	95.4	95.4	—	—
500	95.8	95.8	—	—	95.4	95.8	—	—

Table B-910: Illuminance Categories

NOTE: This table is taken from the *Office Lighting American National Standard Practice*, ANSI/IES RP-1, 1993. The table is produced in its entirety, including captions and footnotes. Permission to reprint is pending.

TABLE 3: Currently recommended illuminance categories for lighting design—target maintained values (See Table 4 for Illuminance Values). These recommendations provide a guide for efficient visual performance in office spaces rather than for safety alone. For a tabulation of minimum levels of illumination required for safety, see Table 7.

Category	Illuminance	Veiling Reflectance
Accounting (see individual tasks)		
Copied Tasks		
Ditto Copy (6)	E	!
Micro fiche reader (1)	B	!!
Mimeograph	D	
Photographs, med. detail	E	!!
Thermal copy, poor copy	F	!
Xerography, 3rd generation (6) and greater	E	
Xerograph	D	
Drafting Tasks		
Drafting: Mylar		
High contrast media; India ink, plastic		
leads, soft graphite leads	E	!
Low contrast media, hard graphite leads	F	!
Vellum: high contrast	E	!
low contrast	F	
Tracing paper: high contrast	E	!
low contrast	F	
Overlays (2)		
Light Table	C	
Prints: Blue Line	E	

	Blueprints	Sepia prints	F
	Illuminance	Veiling	
TABLE 3 (continued)	Category	Reflectance	
EDP Tasks			
CRT Screens (1)	B	!!	
Impact printer: good ribbon	D		
poor ribbon (6)	E		
2nd carbon and greater (6)	E		
Ink jet printer	D		
Keyboard reading	D		
Machine rooms: active operations	D		
tape storage	D		
machine area	C		
equipement service (3)	E		
Thermal print	E	!	
Filing			
(see individual tasks)			
General and Public Areas			
AV areas	D		
Conference rooms	D		
(critical seeing, refer to individual tasks)			
Display areas (4)	C		
Duplicating and off set printing area	D		
Elevators	C		
Escalators	C		
First aid areas	E		
Food service (7)			
Hallways	B		
Janitorial spaces	C		
Libraries (7)			
Lobbies and lounges	C		
Model making	F		
Mail sorting	E		
Mechanical rooms: operation	B		
equipment service (3)	E		

<u>Reception area</u>	<u>C</u>
<u>Rest rooms</u>	<u>G</u>
<u>Stairs</u>	<u>B</u>
<u>Utility rooms</u>	<u>B</u>
<u>Graphic Design and Material</u>	
<u>Color selection (5)</u>	<u>F</u>
<u>Charting and mapping</u>	<u>F</u>
<u>Graphs</u>	<u>E</u>
<u>Keylining</u>	<u>F</u>
<u>Layout and artwork</u>	<u>F</u>
<u>Photographs, mod. detail</u>	<u>E</u>
<u>Handwritten Tasks</u>	
<u>#2 pencil and softer leads</u>	<u>D</u>
<u>#3 pencil</u>	<u>E</u>
<u>#4 pencil and harder leads (6)</u>	<u>F</u>
<u>Ball-point pen</u>	<u>D</u>
<u>Felt tip pen</u>	<u>D</u>
<u>Handwritten carbon copies (6)</u>	<u>E</u>
<u>Non photographically reproducible colors</u>	<u>F</u>
<u>Illuminace</u>	<u>Veiling</u>
TABLE 3 (continued)	Category
	Reflectance
<u>Printed Tasks</u>	
<u>6 pt (6) see 2.4</u>	<u>E</u>
<u>8 & 10 pt</u>	<u>D</u>
<u>Glossy magazines</u>	<u>D</u>
<u>Maps</u>	<u>E</u>
<u>Newsprint</u>	<u>D</u>
<u>Typed Originals</u>	<u>D</u>
<u>Typed 2nd carbon and later (6)</u>	<u>E</u>
<u>Telephone books</u>	<u>E</u>

NOTES:

1. Veiling reflections may be produced on glass surfaces. It may be necessary to treat plus weighting factors as minus in order to obtain proper light balance.
2. Degradation factors: Overlays add 1 weighing factor for each overlay

See Table 4

- ~~3. Only when actual equipment service is in progress. May be achieved by a general lighting system or by localized lighting or by portable equipment.~~
- ~~4. For details on the lighting of display refer to Recommended Practice for Lighting Merchandise Areas. (10)~~
- ~~5. For color matching, the quality of the color of the light source may be important.~~
- ~~6. Designing to higher levels to accommodate poor quality tasks should be undertaken only after it is determined that task quality cannot be improved. If a poor quality task cannot be eliminated, its "time and importance" factor should be carefully considered before allowing it to govern the illuminance level selection.~~
- ~~7. See Reference 9.~~
- ~~! Task subject to veiling reflections. Illuminance listed is not an ESI value. Currently, insufficient experience in the use of ESI target values precludes the direct use of Equivalent Sphere Illumination in the present consensus approach recommend illuminance values. Equivalent Sphere Illumination may be used as a tool in determining the effectiveness of controlling veiling reflections and as part of the evaluation of lighting systems.~~
- ~~!! Especially subject to veiling reflectances. It may be necessary to shield the task or to reorient it.~~

~~Definition of Merchandising and Associated Service Areas in Stores~~

~~NOTE: This table is taken from the Recommended Practice for Lighting Merchandising Areas, IES RP 2. The table is produced in its entirety, including captions and footnotes. Permission to reprint is pending.~~

~~TABLE 1—Currently Recommended Illuminance for Lighting Design in Merchandising and Associated Areas—Target Maintained Levels~~

Areas or Tasks	Description	Type of Activity Area*	Foot Lux candles
Circulation	Area not used for display or appraisal of merchandise	High activity	300 30
		Medium activity	400

Merchandise***	That plane area, horizontal 100	High activity	1000
(including	to vertical, where 75	Medium activity	750
showcases & wall	merchandise is displayed and displays)	Low activity readily accessible for customer examination	300 30
<hr/>			
	Show windows		
	Daytime lighting		
General		2000	200
Feature		10000	1000
<hr/>			
	Nighttime lighting		
	Main business districts		
	highly competitive		
General		2000	200
Feature		10000	1000
<hr/>			
	Secondary business districts		
	or small towns		
General		1000	100
Feature		5000	500
<hr/>			
Sales Transactions	Areas used for employee price verification and for recording transactions	Reading of copied, written, printed or EDP information	See Table 2
<hr/>			
Support Services	Store spaces where merchandising is a prime consideration	Alteration fitting See Table 2	stock, wrapping and packaging rooms

NOTES:

* One store may encompass all three types within the building: High Activity area—where merchandise displayed has recognizable usage. Evaluation and viewing time is rapid, and merchandise is sown to attract and stimulate the impulse buying decision; Medium Activity—where merchandise is familiar in type or usage, but the customer may require time and/or help in evaluation of quality, usage, or for the decision to buy; and Low Activity—where merchandise is displayed that is purchased less frequently by the customer, who may be unfamiliar with the inherent quality, design, value or usage. Where assistance and time is necessary to reach a buying decision.

** Maintained on the task or in the area at any time.

*** Lighting levels to be maintained in the plane of the merchandise.

Fig. 2-1. Currently Recommended Illuminance Categories and Illuminance Values for Lighting Design—Targeted Maintenance Levels.

<p>The tabulation that follows is a consolidated listing of the Society's current illuminance recommendations. This listing is intended to guide the lighting designer in selecting an appropriate illuminance for design and evaluation of lighting systems.</p> <p>Guidance is provided in two forms: (1) in Parts I, II and III as an Illuminance Category, representing a range of illuminances (see page 2-3 for a method of selecting a value within each illuminance range); and (2), in parts IV, V and VI as an Illuminance Value. Illuminance Values are given in lux with an approximate equivalence in footcandles and as such are intended as target (nominal) values with deviations expected. These target values also represent maintained values (see page 2-23).</p>	<p>This table has been divided into the six parts for ease of use. Part I provides a listing of both Illuminance Categories and Illuminance Values for generic types of interior activities and normally is to be used when Illuminance Categories for a specific Area/Activity cannot be found in parts II and III. Parts IV, V and VI provide target maintained Illuminance Values for outdoor facilities, sports and recreational areas, and transportation vehicles where special considerations apply as discussed on page 2-4.</p> <p>In all cases the recommendations in this table are based on the assumption that the lighting will be properly designed to take into account the visual characteristics of the task. See the design information in the particular application sections in this Application Handbook for further recommendations.</p>												
II. Commercial, Institutional, Residential and Public Assembly Interiors													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Area/Activity</th> <th style="text-align: left;">Category</th> <th style="text-align: left;">Illuminance</th> <th style="text-align: left;">Illuminance</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Area/Activity	Category	Illuminance	Illuminance					<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Area/Activity</th> <th style="text-align: left;">Category</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> </tr> </tbody> </table>	Area/Activity	Category		
Area/Activity	Category	Illuminance	Illuminance										
Area/Activity	Category												

2005 Nonresidential ACM Manual, Express Terms, 15-Day Language Page NB-128

Accounting (see Reading)	Court rooms
Air terminals (see Transportation terminals)	Seating area C
Armories C ¹	Court activity area E ³
Art galleries (see Museums)	Dance halls and discotheques B
Auditoriums	Depots, terminals and stations
Assembly C ¹	(see Transportation terminals)
Social activity B	Drafting
Banks	Mylar
Lobby	High contrast media; India ink, plastic leads, soft graphite
General C	leads E ³
Writing area D	Low contrast media; hard graphite leads F ³
Tellers' stations E ³	Vellum
Barber shops and beauty parlors E	High contrast E ³
Churches and synagogues (see page 7-2) ⁴	Low contrast F ³
Club and lodge rooms	Tracing paper
Lounge and reading D	High contrast E ³
Conference rooms	Low contrast F ³
Conferring D	Overlays ⁵
Critical seeing (refer to individual task)	Light table C
	Prints
	Blue-line E
	Blueprints E
	Sepia prints F

NOTE: This table is taken from the Figure 2-2 of the IES
Lighting Handbook 1982 Application Volume, Part
II of the table is produced in its entirety, with
captions and footnotes. Permission to reprint is pending.

Fig. 2-1. Continued

II. Continued

Area/Activity	Illuminance	Illuminance
Category	Area/Activity	Category

Educational facilities	
Classrooms	Layout and artwork F
General (see Reading)	Photographs, moderate detail E ¹³
Drafting (see Drafting)	
Home economics (see Residences)	Health care facilities
Science laboratories	Ambulance (local) E
E	Anesthetizing E
Lecture rooms	Autopsy and morgue ¹⁷⁻¹⁸
Audience (see Reading)	Autopsy, general E
Demonstration	Autopsy table G
F	Morgue, general D
Music rooms (see Reading)	Museum E
Shops (see Part III, Industrial Group)	
Sight saving rooms F	
Study halls (see Reading)	
Typing (see Reading)	
Sports facilities (see Part V, Sports and Recreational Areas)	
Cafeterias (see Food service facilities)	
Dormitories (see Residences)	
Elevator, freight and passenger C	
Exhibition halls C ⁴	
Filing (refer to individual task)	
Financial facilities (see Banks)	
Fire halls (see Municipal buildings)	
Food service facilities	
Dining areas	
Cashier D	
Cleaning C	
Dining B ⁶	
Food displays (see Merchandising spaces)	
Kitchen E	
Garages parking (see page 14-28)	
Gasoline stations (see Service stations)	
Graphic design and material	
Color selection F ¹⁴	
Charting and mapping F	
Graphs E	

Cardiac function lab	E		Dialysis unit, medical ¹⁷	F
Central sterile supply			Elevators	C
Inspection, general	E		EKG and specimen room ¹⁷	
Inspection	F		General	B
At sinks	E		On equipment	C
Work areas, general	D		Emergency outpatient ¹⁷	
Processed storage	D		General	E
Corridors ¹⁷			Local	F
Nursing areas—day	C		Endoscopy rooms ^{17,18}	
Nursing areas—night	B		General	E
Operating areas, delivery, recovery, and laboratory suites and service	E		Peritoneoscopy	D
Critical care areas ¹⁷			Culdoscopy	D
General	C		Examination and treatment rooms ¹⁷	
Examination	E		General	D
Surgical task lighting	H		Local	E
Hand washing	F		Eye surgery ^{17,18}	F
Cystoscopy room ^{17,18}			Fracture room ¹⁷	
Dental suite ¹⁷			General	E
General	D		Local	F
Instrument tray	E		Inhalation therapy	D
Oral Cavity	H		Laboratories ¹⁷	
Prosthetic laboratory, general	D		Specimen collecting	E
Prosthetic laboratory, work bench	E		Tissue laboratories	F
Prosthetic, laboratory, local	F		Microscopic reading room	D
Recovery room, general	G		Gross specimen review	F
Recovery room, emergency			Chemistry rooms	E

Fig. 2-1. Continued

II. Continued

Area/Activity	Category	Area/Activity	Category
---------------	----------	---------------	----------

Bacteriology rooms	
General	E
Reading culture plates	
F	
Hematology	E
Linens	
Sorting soiled linen	D
Central (clean) linen room	D
Sewing room, general	D
Sewing room, work area	E
Linen closet	B
Lobby	C
Locker rooms	C
Medical illustration studio ^{17, 18}	F
Medical records	E
Nurseries ¹⁷	
General ¹⁸	C
Observation and treatment	E
Nursing stations ¹⁷	
General	D
Desk	E
Corridors, day	C
Corridors, night	A
Medication station	E
Obstetric delivery suite ¹⁷	
Labor rooms	
General	C
Local	E
Birthing room	F
Delivery area	
Scrub, general	F
General	G
Delivery table	(see page 7-19)
Resuscitation	G
Post delivery recovery area	E
Substerilizing room	B
Occupational therapy ¹⁷	
Work area, general	D
Work tables or benches	E
Patients' rooms ¹⁷	
General ¹⁸	B
Observation	A
Critical examination	E
Reading	D
Toilets	D
Pharmacy ¹⁷	

<u>Radiological suite</u> ¹⁷	Toilets	C
<u>Diagnostic section</u>	<u>Utility room</u>	D
<u>General</u> ¹⁸ A	<u>Waiting areas</u> ¹⁷	
<u>Waiting area</u> A	<u>General</u> C	
<u>Radiographic/fluorescopic room</u> A	<u>Local for reading</u> D	
<u>Film sorting</u> F	<u>Homes</u> (see <u>Residences</u>)	
<u>Barium kitchen</u> E	<u>Hospitality facilities</u>	
<u>Radiation therapy section</u>	(see <u>Hotels</u> , <u>food service facilities</u>)	
<u>General</u> ¹⁸ B	<u>Hospitals</u> (see <u>Health care facilities</u>)	
<u>Waiting area</u> B	<u>Hotels</u>	
<u>Isotope kitchen, general</u> E	<u>Bathrooms, for grooming</u> D	
<u>Isotope kitchen, benches</u> E	<u>Bedrooms, for reading</u> D	
<u>Computerized radiotomography section</u>	<u>Corridors, elevators and stairs</u> C	
<u>Scanning room</u> B	<u>Front desk</u> E ³	
<u>Equipment maintenance room</u> E	<u>Linen room</u>	
<u>Solarium</u>	<u>Sewing</u> F	
<u>General</u> C	<u>General</u> C	
<u>Local for reading</u> D	<u>Lobby</u>	
<u>Stairways</u> C	<u>General lighting</u> C	
<u>Surgical suite</u> ¹⁷	<u>Reading and working areas</u> D	
<u>Operating room, general</u> ¹⁸ F	<u>Canopy</u> (see Part IV, <u>Outdoor Facilities</u>)	
<u>Operating table</u> (see page 7-15)	<u>Houses of worship</u> (see page 7-5)	
<u>Scrub room</u> F	<u>Kitchens</u> (see <u>Food service facilities</u> or <u>Residences</u>)	
<u>Instruments and sterile supply room</u> D	<u>Libraries</u>	
<u>Clean up room, instruments</u> E	<u>Reading areas</u> (see <u>Reading</u>)	
<u>Anesthesia</u> C		
<u>Substerilizing room</u> C		
<u>Surgical induction room</u> ^{17, 18} E		
<u>Surgical holding area</u> ^{17, 18} E		

Fig. 2-1. Continued																																																																																																																											
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Parking facilities (see page 14-28)

#2 pencil and softer leads D³

Post offices (see Offices)

#3 pencil E³**Reading**#4 pencil and harder leads F³

Copied tasks

Ball point pen D³Ditto copy E³

Felt tip pen D

Micro fiche reader B^{12,13}Handwritten carbon copies E
Non photographically reproducible colors F

Mimeograph D

Chalkboards E³Photograph, moderate detail E¹³

Printed tasks

Thermal copy, poor copy F³6 point type E³

Xerography D

8 and 10 point type D³

Xerography, 3rd generation and greater E

Glossy magazines D¹³

Electronic data processing tasks

Maps E

CRT screens B^{12,13}

Newsprint D

Impact printer

Typed originals D

good ribbon D

Typed 2nd carbon and later E

poor ribbon E

Telephone books E

2nd carbon and greater

Residences

E

General lighting

Ink jet printer D

Conversation, relaxation and entertainment B

Keyboard reading D

Passage areas B

Machine rooms

Specific visual tasks²⁰

Active operations D

Dining C

Tape storage D

Grooming

Machine area C

Makeup and shaving D

Equipment service E¹⁰

Full-length mirror D

Thermal print E

Handwritten tasks

<u>Fig. 2-1. Continued</u>		<u>D</u>
<u>II. Continued</u>		<u>Primary task plane, study</u>
<u>Illuminance</u>		<u>E</u>
<u>Illuminance</u>		<u>Sewing</u>
<u>Area/Activity</u>		<u>Hand sewing</u>
<u>Category</u>		<u>Dark fabrics, low contrast</u>
<u>Area/Activity</u>		<u>F</u>
<u>Category</u>		<u>Light to medium fabrics</u>
<u>Category</u>		<u>E</u>
<u>Handcrafts and hobbies</u>		<u>Occasional, high contrast</u>
<u>Workbench hobbies</u>		<u>D</u>
<u>Ordinary tasks</u>		<u>Machine sewing</u>
<u>Difficult tasks</u>		<u>Dark fabrics, low contrast</u>
<u>Critical tasks</u>		<u>F</u>
<u>Easel hobbies</u>		<u>Light to medium fabrics</u>
<u>Ironing</u>		<u>E</u>
<u>Kitchen duties</u>		<u>Occasional, high contrast</u>
<u>Kitchen counter</u>		<u>D</u>
<u>Critical seeing</u>		<u>Table games</u>
<u>Noncritical</u>		
<u>Kitchen range</u>		
<u>Difficult seeing</u>		
<u>Noncritical</u>		
<u>Kitchen sink</u>		
<u>Difficult seeing</u>		
<u>Noncritical</u>		
<u>Laundry</u>		
<u>Preparation and tubs</u>		
<u>D</u>		
<u>Washer and dryer</u>		
<u>Music study (piano or organ)</u>		
<u>Simple scores</u>		
<u>Advanced scores</u>		
<u>Substandard size scores</u>		
<u>F</u>		
<u>Reading</u>		<u>Restaurants (see Food service facilities)</u>
<u>In a chair</u>		
<u>Books, magazines and newspapers</u>		<u>Safety (see page 2-45)</u>
<u>Handwriting, reproductions and</u>		
<u>poor copies</u>		<u>Schools (see Educational facilities)</u>
<u>E</u>		
<u>In bed</u>		<u>Service spaces (see also Storage rooms)</u>
<u>Normal</u>		<u>Stairways, corridors G</u>
<u>Prolonged serious or critical</u>		<u>Elevators, freight and passenger G</u>
<u>Desk</u>		<u>Toilet and washroom G</u>
		<u>Service stations</u>

Sales room (see Merchandising spaces)

Show windows (see page 8-7)

Stairways (see Service spaces)

Storage rooms (see Part III, Industrial Group)

Stores (see Merchandising spaces and Show windows)

Television (see Section 11)

Toilets and washrooms C

Transportation terminals

Waiting room and lounge C

Ticket counters E

Baggage checking D

Rest rooms C

Concourse B

Boarding area C

¹Include provisions for higher levels for exhibitions.

²Specific limits are provided to minimize deterioration effects.

³Task subject to veiling reflections. Illuminance listed is not an Equivalent Sphere Illumination (ESI) value. Currently, insufficient experience in the use of ESI target values precludes the direct use of ESI in the present consensus approach to recommend illuminance values. ESI may be used as a tool in determining the effectiveness of controlling veiling reflections and as a part of the evaluation of lighting systems.

⁴Illuminance values are listed based on experience and consensus. Values relate to needs during various religious ceremonies.

⁵Degradation factors: Overlays—add 2 weighting factor for each overlay; Used material—estimate additional factors.

⁶Provide higher level over food service or selection areas.

⁷Supplementary illumination as in delivery room must be available.

⁸Illuminance values developed for various degrees of store area activity.

⁹Or not less than 1/5 the level in the adjacent areas.

¹⁰Only when actual equipment service is in process. May be achieved by a general lighting system or by localized or portable equipment.

¹¹For color matching, the spectral quality of the color of the light source is important.

¹²Veiling reflections may be produced on glass surfaces. It may be necessary to treat plus weighting factors as minus in order to obtain proper illuminance.

¹³Especially subject to veiling reflections. It may be necessary to shield the task or to reorient it.

¹⁴Vertical

¹⁵Illuminance values may vary widely, depending upon the effect desired, the decorative scheme, and the use made of the room.

¹⁶Supplementary lighting should be provided in this space to produce the higher levels required for specific seeing tasks involved.

¹⁷Good to high color rendering capability should be considered in these areas. As lamps of higher luminous efficacy and higher color rendering capability become available and economically feasible, they should be applied in all areas of health care facilities.

¹⁸Variable (dimming or switching).

¹⁹Values based on a 25 percent reflectance, which is average for vegetation and typical outdoor surfaces. These figures must be adjusted to specific reflectances of materials lighted for equivalent brightness. Levels give satisfactory brightness patterns when viewed from dimly lighted terraces or interiors. When viewed from dark areas they may be reduced by at least 1/2, or they may be doubled when a high key is desired.

²⁰General lighting should not be less than 1/3 of visual task illuminance nor less than 200 lux [20 footcandles].

²¹Industry representatives have established a table of single illuminance values which, in their opinion, can be used in preference to employing reference 6. Illuminance values for specific operations can also be determined using illuminance categories of similar tasks and activities found in this table and the application of the appropriate weighting factors in Fig. 2-3.

²²Special lighting such that (1) the luminous area is large enough to cover the surface, which is being inspected and (2) the luminance is within the limits necessary to obtain comfortable contrast conditions. This involves the use of sources of large area and relatively low luminance in which the source luminance is the principal factor rather than the illuminance produced at a given point.

²³Maximum levels—controlled system.

²⁴Additional lighting needs to be provided for maintenance only.

²⁵Color temperature of the light source is important for color matching.

²⁶Select upper level for high speed conveyor systems. For grading redwood lumber 3000 lux [300 footcandles] is required.

²⁷Higher levels from local lighting may be required for manually operated cutting machines.

²⁸If color matching is critical, use illuminance category G.

LUMINAIRE POWER

Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Fluorescent Circline								
Fluorescent Circline, Rapid Start (22 W)								
4	FC8T9	1	MAG-STD	Magnetic Standard	27	8" OD		
Fluorescent Circline, Rapid Start (32 W)								
4	FC12T9	1	MAG-STD	Magnetic Standard	45	12" OD		
Fluorescent Circline, Rapid Start (40 W)								
4	FC16T9	1	MAG-STD	Magnetic Standard	57	16" OD		
Fluorescent 2D								
Compact Fluorescent 2D (10W, GR10q-4 Four Pin Base)								
4	CFS10W/GR10q	1	MAG-STD	Magnetic Standard	16	3.6" across		
4	CFS10W/GR10q	1	ELECT	Electronic	13			
2	CFS10W/GR10q	1	ELECT	Electronic	26			
Compact Fluorescent 2D (16W, GR10q-4 Four Pin Base)								
4	CFS16W/GR10q	1	MAG-STD	Magnetic Standard	23	5.5" across		
4	CFS16W/GR10q	1	ELECT	Electronic	15			
2	CFS16W/GR10q	1	ELECT	Electronic	30			
Compact Fluorescent 2D (21W, GR10q-4 Four Pin Base)								
4	CFS21W/GR10q	1	MAG-STD	Magnetic Standard	31	5.5" across		
4	CFS21W/GR10q	1	ELECT	Electronic	24			
2	CFS21W/GR10q	1	ELECT	Electronic	42			
Compact Fluorescent 2D (28W, GR10q-4 Four Pin Base)								
4	CFS28W/GR10q	1	MAG-STD	Magnetic Standard	38	8.1" across		
4	CFS28W/GR10q	1	ELECT	Electronic	28			

2	CFS28W/GR10q	1	ELECT	Electronic	56	
Compact Fluorescent 2D (38W, GR10q-4 Four Pin Base)						
4	CFS38W/GR10q	1	ELECT	Electronic	37	8.1" across
2	CFS38W/GR10q	1	ELECT	Electronic	74	
Compact Fluorescent Twin - Two Pin Base						
Compact Fluorescent Twin (5 W, G23 Two Pin Base - F5TT Lamp)						
4	CFT5W/G23	1	MAG STD	Magnetic Standard	9	4.1" MOL
2	CFT5W/G23	2	MAG STD	Magnetic Standard	18	
Compact Fluorescent Twin (7 W, G23 Two Pin Base - F7TT Lamp)						
4	CFT7W/G23	1	MAG STD	Magnetic Standard	11	5.3" MOL
2	CFT7W/G23	2	MAG STD	Magnetic Standard	22	

LUMINAIRE POWER

Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Compact Fluorescent Twin - Two Pin Base (cont.)								
Compact Fluorescent Twin (9 W, G23 Two Pin Base - F9TT Lamp)								
4	CFT9W/G23	1	MAG STD	Magnetic Standard	13	6.5" MOL		
2	CFT9W/G23	2	MAG STD	Magnetic Standard	26			
Compact Fluorescent Twin (13 W, GX23 Two Pin Base - F13TT)								
4	CFT13W/GX23	1	MAG STD	Magnetic Standard	17	7.5" MOL		
2	CFT13W/GX23	2	MAG STD	Magnetic Standard	34			
Compact Fluorescent Quad - Two Pin Base								
Compact Fluorescent Quad (9 W, G23-2 Two Pin Base - F9DTT Lamp)								
4	CFQ9W/G23-2	1	MAG STD 120	120 V Magnetic Standard	13	4.4" MOL		
2	CFQ9W/G23-2	2	MAG STD 120	120 V Magnetic Standard	26			
Compact Fluorescent Quad (13 W, G24d-1 Two Pin Base - F13DTT Lamp)								
4	CFQ13W/G24d-1	1	MAG STD 120	120 V Magnetic Standard	18	6.0" MOL		
2	CFQ13W/G24d-1	2	MAG STD 120	120 V Magnetic Standard	36			
4	CFQ13W/G24d-1	1	MAG STD 277	227 V Magnetic Standard	16			
2	CFQ13W/G24d-1	2	MAG STD 277	227 V Magnetic Standard	32			

Compact Fluorescent Quad (13 W, GX23-2 Two Pin Base)						
4	CFQ13W/GX23-2	1	MAG-STD	Magnetic Standard	17	4.8" MOL
2	CFQ13W/GX23-2	2	MAG-STD	Magnetic Standard	34	
Compact Fluorescent Quad (16W GX32d-1 Two Pin Base)						
4	CFQ16W/GX32d-1	1	MAG-STD	Magnetic Standard	20	5.5" MOL
2	CFQ16W/GX32d-1	2	MAG-STD	Magnetic Standard	40	
Compact Fluorescent Quad (18 W, G24d-2 Two Pin Base - F18DTT Lamp)						
4	CFQ18W/G24d-2	1	MAG-STD-120	120 V Magnetic Standard	25	6.8" MOL
2	CFQ18W/G24d-2	2	MAG-STD-120	120 V Magnetic Standard	50	
4	CFQ18W/G24d-2	1	MAG-STD-277	227 V Magnetic Standard	22	
2	CFQ18W/G24d-2	2	MAG-STD-277	227 V Magnetic Standard	44	
Compact Fluorescent Quad (22W, GX32d Two Pin Base)						
4	CFQ22W/GX32d-2	1	MAG-STD	Magnetic Standard	27	6.0" MOL
2	CFQ22W/GX32d-2	2	MAG-STD	Magnetic Standard	54	
Compact Fluorescent Quad (26 W, G24d-3 Two Pin Base - F26DTT Lamp)						
4	CFQ26W/G24d-3	1	MAG-STD-120	120 V Magnetic Standard	37	7.6" MOL
2	CFQ26W/G24d-3	2	MAG-STD-120	120 V Magnetic Standard	74	
4	CFQ26W/G24d-3	1	MAG-STD-277	227 V Magnetic Standard	33	
2	CFQ26W/G24d-3	2	MAG-STD-277	227 V Magnetic Standard	66	
4	CFQ26W/G24d-3	1	ELECT-277V	277 V Electronic	27	
2	CFQ26W/G24d-3	2	ELECT-277V	277 V Electronic	54	

LUMINAIRE POWER

Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments
No.	Designation	No.	Abbreviation	Description		
Compact Fluorescent Quad - Two Pin Base (cont.)						
Compact Fluorescent Quad (28W GX32d Two Pin Base)						
4	CFQ28W/GX32d-3	1	MAG-STD	Magnetic Standard	34	6.8" MOL
2	CFQ28W/GX32d-3	2	MAG-STD	Magnetic Standard	68	
Compact Fluorescent Quad - Four Pin Base						
Compact Fluorescent Quad (10 W, G24q-1 Four Pin Base)						
4	CFQ10W/G24q-1	1	MAG-STD-120	120 V Magnetic Standard	16	4.6" MOL

2	CFQ10W/G24q-1	2	MAG STD 120	120 V Magnetic Standard	32	
4	CFQ10W/G24q-1	1	MAG STD 277	227 V Magnetic Standard	13	
2	CFQ10W/G24q-1	2	MAG STD 277	227 V Magnetic Standard	26	
Compact Fluorescent Quad (13 W, G24q-1 Four Pin Base)						
4	CFQ13W/G24q-1	1	MAG STD 120	120 V Magnetic Standard	18	6.0" MOL
2	CFQ13W/G24q-1	2	MAG STD 120	120 V Magnetic Standard	36	
4	CFQ13W/G24q-1	1	MAG STD 277	227 V Magnetic Standard	16	
2	CFQ13W/G24q-1	2	MAG STD 277	227 V Magnetic Standard	32	
Compact Fluorescent Quad (13 W, GX7 Four Pin Base)						
4	CFQ13W/GX7	1	MAG STD	Magnetic Standard	17	4.8" MOL
2	CFQ13W/GX7	2	MAG STD	Magnetic Standard	34	
Compact Fluorescent Quad (18 W, G24q-2 Four Pin Base)						
4	CFQ18W/G24q-2	1	MAG STD 120	120 V Magnetic Standard	25	6.8" MOL
2	CFQ18W/G24q-2	2	MAG STD 120	120 V Magnetic Standard	50	
4	CFQ18W/G24q-2	1	MAG STD 277	227 V Magnetic Standard	22	
2	CFQ18W/G24q-2	2	MAG STD 277	227 V Magnetic Standard	44	
Compact Fluorescent Triple - Four Pin Base						
Compact Fluorescent Triple (13 W, GX24q-1 Four Pin Base)						
4	GFM-13W/GX24q-1	1	MAG STD	Magnetic Standard	18	4.2" MOL
2	GFM-13W/GX24q-1	2	MAG STD	Magnetic Standard	36	
Compact Fluorescent Triple (18W, GX24q-2 Four Pin Base)						
4	GFM-18W/GX24q-2	1	MAG STD	Magnetic Standard	25	5.0" MOL
2	GFM-18W/GX24q-2	2	MAG STD	Magnetic Standard	50	
Compact Fluorescent Triple (26W, GX24q-3 Four Pin Base)						
4	GFM-26W/GX24q-3	1	MAG STD	Magnetic Standard	37	4.9 to 5.4" MOL
2	GFM-26W/GX24q-3	2	MAG STD	Magnetic Standard	74	

LUMINAIRE POWER**Table B-101**

Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Fluorescent Twin								
Fluorescent Twin (18W F18TT Lamp)								

4	FT18W/2G11	1	MAG-EE	Magnetic Energy Efficient	23	
2	FT18W/2G11	1	MAG-EE	Magnetic Energy Efficient	46	
3	FT18W/2G11	1.5	MAG-EE	Magnetic Energy Efficient	69	Tandem-wired
3	FT18W/2G11	2	MAG-EE	Magnetic Energy Efficient	69	
4	FT18W/2G11	2	MAG-EE	Magnetic Energy Efficient	92	(2) Two-lamp ballasts
4	FT18W/2G11	1	ELECT	Electronic	17	
2	FT18W/2G11	1	ELECT	Electronic	35	
3	FT18W/2G11	1.5	ELECT	Electronic	52	Tandem-wired
3	FT18W/2G11	2	ELECT	Electronic	52	
4	FT18W/2G11	2	ELECT	Electronic	70	(2) Two-lamp ballasts
Fluorescent Twin (24-27W - F24TT or F27TT Lamp)						
4	FT24W/2G11	1	MAG-EE	Magnetic Energy Efficient	32	
2	FT24W/2G11	1	MAG-EE	Magnetic Energy Efficient	66	
3	FT24W/2G11	1.5	MAG-EE	Magnetic Energy Efficient	99	Tandem-wired
3	FT24W/2G11	2	MAG-EE	Magnetic Energy Efficient	98	
4	FT24W/2G11	2	MAG-EE	Magnetic Energy Efficient	132	(2) Two-lamp ballasts
4	FT24W/2G11	1	ELECT	Electronic	24	
2	FT24W/2G11	1	ELECT	Electronic	43	
3	FT24W/2G11	1.5	ELECT	Electronic	64	Tandem-wired
3	FT24W/2G11	2	ELECT	Electronic	64	
4	FT24W/2G11	2	ELECT	Electronic	86	(2) Two-lamp ballasts
Fluorescent Twin (36-39W - F36TT or F39TT Lamp)						
4	FT36W/2G11	1	MAG-EE	Magnetic Energy Efficient	51	
2	FT36W/2G11	1	MAG-EE	Magnetic Energy Efficient	66	
3	FT36W/2G11	1.5	MAG-EE	Magnetic Energy Efficient	99	Tandem-wired
3	FT36W/2G11	2	MAG-EE	Magnetic Energy Efficient	117	
4	FT36W/2G11	2	MAG-EE	Magnetic Energy Efficient	132	(2) Two-lamp ballasts
4	FT36W/2G11	1	ELECT	Electronic	37	
2	FT36W/2G11	1	ELECT	Electronic	70	

3	FT36W/2G11	1.5	ELECT	Electronic	105	Tandem-wired
3	FT36W/2G11	2	ELECT	Electronic	107	
4	FT36W/2G11	2	ELECT	Electronic	140	(2) Two-lamp ballasts

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Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Fluorescent Twin (cont.)								
Fluorescent Twin (40 W - F40TT Lamp)								
1	FT40W/2G11	1	MAG EE	Magnetic Energy Efficient	43			
2	FT40W/2G11	1	MAG EE	Magnetic Energy Efficient	86			
3	FT40W/2G11	1.5	MAG EE	Magnetic Energy Efficient	129	Tandem wired		
3	FT40W/2G11	2	MAG EE	Magnetic Energy Efficient	130			
4	FT40W/2G11	2	MAG EE	Magnetic Energy Efficient	172	(2) Two lamp ballasts		
4	FT40W/2G11	1	ELECT	Electronic	36			
2	FT40W/2G11	1	ELECT	Electronic	71			
2	FT40W/2G11	1	ELECT	Electronic	70			
3	FT40W/2G11	1	ELECT	Electronic	98			
3	FT40W/2G11	1.5	ELECT	Electronic	106	Tandem wired		
3	FT40W/2G11	2	ELECT	Electronic	107			
4	FT40W/2G11	2	ELECT	Electronic	142	(2) Two lamp ballasts		
2	FT40W/2G11	1	ELECT RO	Elec. Reduce Output (75%)	59			
3	FT40W/2G11	1.5	ELECT DIM	Electronic Dimming (to 1%)	105	Tandem wired		
4	FT40W/2G11	2	ELECT DIM	Electronic Dimming (to 1%)	140	(2) two lamp ballasts		
Fluorescent Twin (50 W - F50TT Lamp)								
4	FT50W/2G11	1	ELECT	Electronic	54			
2	FT50W/2G11	1	ELECT	Electronic	106			
3	FT50W/2G11	1	ELECT	Electronic	98			
3	FT50W/2G11	1.5	ELECT	Electronic	159	Tandem wired		
3	FT50W/2G11	2	ELECT	Electronic	160			
4	FT50W/2G11	2	ELECT	Electronic	212	(2) Two lamp		

Fluorescent Twin (55 W F55TT Lamp)						ballasts
4	FT55W/2G11	1	ELECT	Electronic	62	
Fluorescent U-Tube*						
2 ft. Fluorescent U-Tube Octic (32W FBO31T8 Lamp)						
4	FB31T8	0.5	MAG EE	Magnetic Energy Efficient	35	Tandem wired
4	FB31T8	1	MAG EE	Magnetic Energy Efficient	36	
2	FB31T8	1	MAG EE	Magnetic Energy Efficient	69	
3	FB31T8	1.5	MAG EE	Magnetic Energy Efficient	104	Tandem wired
3	FB31T8	2	MAG EE	Magnetic Energy Efficient	105	

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Lamp		Ballast			Watts/ Luminaire	Comments
No.	Designation	No.	Abbreviation	Description		
Fluorescent U-Tube* (cont.)						
4	FB31T8	0.5	ELECT	Electronic	34	Tandem wired
4	FB31T8	1	ELECT	Electronic	39	
2	FB31T8	1	ELECT	Electronic	62	
3	FB31T8	1	ELECT	Electronic	92	
3	FB31T8	1.5	ELECT	Electronic	93	Tandem wired
3	FB31T8	2	ELECT	Electronic	101	
2	FB31T8	1	ELECT IS	Electronic Instant Start	61	
3	FB31T8	1	ELECT IS	Electronic Instant Start	88	
2 ft. Fluorescent U-Tube Energy Saving (34W)						
4	FB40T12/ES	0.5	MAG EE	Magnetic Energy Efficient	36	Tandem wired
4	FB40T12/ES	1	MAG EE	Magnetic Energy Efficient	43	
2	FB40T12/ES	1	MAG EE	Magnetic Energy Efficient	72	
3	FB40T12/ES	1	MAG EE	Magnetic Energy Efficient	105	
3	FB40T12/ES	1.5	MAG EE	Magnetic Energy Efficient	108	Tandem wired
3	FB40T12/ES	2	MAG EE	Magnetic Energy Efficient	115	
4	FB40T12/ES	0.5	ELECT	Electronic	30	Tandem wired

4	FB40T12/ES	1	ELECT	Electronic	31	
2	FB40T12/ES	1	ELECT	Electronic	59	
3	FB40T12/ES	1	ELECT	Electronic	90	
3	FB40T12/ES	1.5	ELECT	Electronic	88	Tandem-wired
3	FB40T12/ES	2	ELECT	Electronic	90	
2 ft. Fluorescent U-Tube Standard (40W FB40T12 Lamp)						
4	FB40T12	0.5	MAG-EE	Magnetic Energy Efficient	43	Tandem-wired
4	FB40T12	1	MAG-EE	Magnetic Energy Efficient	48	
2	FB40T12	1	MAG-EE	Magnetic Energy Efficient	86	
3	FB40T12	1	MAG-EE	Magnetic Energy Efficient	127	
3	FB40T12	1.5	MAG-EE	Magnetic Energy Efficient	129	Tandem-wired
3	FB40T12	2	MAG-EE	Magnetic Energy Efficient	134	
4	FB40T12	0.5	ELECT	Electronic	35	Tandem-wired
4	FB40T12	1	ELECT	Electronic	36	
2	FB40T12	1	ELECT	Electronic	67	
3	FB40T12	1	ELECT	Electronic	100	
3	FB40T12	1.5	ELECT	Electronic	101	Tandem-wired
3	FB40T12	2	ELECT	Electronic	103	

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Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Fluorescent Preheat								
Fluorescent Preheat T5 (4W)								
4	F4T5	1	MAG-STD	Magnetic Standard	8	6" MOL		
Fluorescent Preheat T5 (6W)								
4	F6T5	1	MAG-STD	Magnetic Standard	10	9" MOL		
Fluorescent Preheat T5 (8W)								
4	F8T5	1	MAG-STD	Magnetic Standard	12	12" MOL		
Fluorescent Preheat T8 (15W)								
4	F15T8	1	MAG-STD	Magnetic Standard	19	18" MOL		
Fluorescent Preheat T12 (15W)								

4	F15T12	1	MAG-STD	Magnetic Standard Fluorescent Preheat T12 (20W)	19	18" MOL
4	F20T12	1	MAG-STD	Magnetic Standard	25	24" MOL
2	F20T12	1	MAG-STD	Magnetic Standard Fluorescent Preheat T8 (30W)	50	24" MOL
4	F30T8	1	MAG-STD	Magnetic Standard	46	30" MOL
2	F30T8	1	MAG-STD	Magnetic Standard Fluorescent Preheat T12 (30W)	79	30" MOL
4	F30T12	1	MAG-STD	Magnetic Standard	46	30" MOL
2	F30T12	1	MAG-STD	Magnetic Standard	79	30" MOL
2	F30T12	1	MAG-EE	Magnetic Energy Efficient	74	30" MOL
1	F30T12	1	ELECT	Electronic	31	30" MOL
2	F30T12	2	ELECT	Electronic	63	30" MOL
Fluorescent Rapid Start T8 (17W and 25W)						
2-foot Fluorescent Rapid Start T8 (17W)						
4	F17T8	1	MAG-EE	Magnetic Energy Efficient	24	
2	F17T8	1	MAG-EE	Magnetic Energy Efficient	45	
4	F17T8	1	ELECT	Electronic	22	
2	F17T8	1	ELECT	Electronic	33	
3	F17T8	1	ELECT	Electronic	53	
3	F17T8	2	ELECT	Electronic	55	
4	F17T8	1	ELECT	Electronic	63	
4	F17T8	2	ELECT	Electronic	66	(2) two-lamp ballasts

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Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Fluorescent Rapid Start T8 (17W and 25W) (cont.)								
3-foot Fluorescent Rapid Start T8 (25W)								
4	F25T8	1	MAG-EE	Magnetic Energy Efficient	33			
2	F25T8	1	MAG-EE	Magnetic Energy Efficient	65			

4	F25T8	1	ELECT	Electronic	27	
2	F25T8	1	ELECT	Electronic	48	
3	F25T8	1	ELECT	Electronic	68	
3	F25T8	2	ELECT	Electronic	75	
4	F25T8	1	ELECT	Electronic	89	
4	F25T8	2	ELECT	Electronic	96	(2) two lamp ballasts

Fluorescent Rapid Start T8 (32W and 40W)

4 foot Fluorescent Rapid Start Octic (32W)						
4	F32T8	0.5	MAG-EE	Magnetic Energy Efficient	35	Tandem-wired
4	F32T8	1	MAG-EE	Magnetic Energy Efficient	39	
2	F32T8	1	MAG-EE	Magnetic Energy Efficient	70	
3	F32T8	1.5	MAG-EE	Magnetic Energy Efficient	105	Tandem-wired
3	F32T8	2	MAG-EE	Magnetic Energy Efficient	109	
4	F32T8	2	MAG-EE	Magnetic Energy Efficient	140	(2) two lamp ballasts
4	F32T8	0.5	ELECT	Electronic	31	Tandem-wired
4	F32T8	1	ELECT	Electronic	32	
2	F32T8	1	ELECT	Electronic	62	
3	F32T8	1	ELECT	Electronic	93	
3	F32T8	1.5	ELECT	Electronic	93	Tandem-wired
3	F32T8	2	ELECT	Electronic	94	
4	F32T8	1	ELECT	Electronic	114	
4	F32T8	2	ELECT	Electronic	124	(2) two lamp ballasts
2	F32T8	1	ELECT-IS	Electronic Instant Start	63	
3	F32T8	1	ELECT-IS	Electronic Instant Start	96	
3	F32T8	1.5	ELECT-IS	Electronic Instant Start	95	Tandem-wired
4	F32T8	1	ELECT-IS	Electronic Instant Start	124	
4	F32T8	2	ELECT-IS	Electronic Instant Start	126	(2) two lamp ballasts

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Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Fluorescent Rapid Start T8 (32W and 40W) (cont.)								
4-foot Fluorescent Rapid Start Octic (32W) (cont.)								
2	F32T8	1	ELECTRO	Electronic Reduce Output (75%)	51			
3	F32T8	1	ELECTRO	Electronic Reduce Output (75%)	76			
3	F32T8	1.5	ELECTRO	Electronic Reduce Output (75%)	77	Tandem wired		
4	F32T8	1	ELECTRO	Electronic Reduce Output (75%)	100			
4	F32T8	2	ELECTRO	Electronic Reduce Output (75%)	102	(2) two lamp ballasts		
2	F32T8	1	ELECT TL	Electronic Two Level (50 & 100%)	65			
3	F32T8	1.5	ELECT TL	Electronic Two Level (50 & 100%)	98	Tandem wired		
4	F32T8	2	ELECT TL	Electronic Two Level (50 & 100%)	130	(2) two lamp ballasts		
2	F32T8	1	ELECT AO	Electronic Adjustable Output (to 15%)	73			
3	F32T8	1.5	ELECT AO	Electronic Adjustable Output (to 15%)	110	Tandem wired		
4	F32T8	2	ELECT AO	Electronic Adjustable Output (to 15%)	146	(2) two lamp ballasts		
2	F32T8	1	ELECT DIM	Electronic Dimming (to 1%)	75			
3	F32T8	1.5	ELECT DIM	Electronic Dimming (to 1%)	113	Tandem wired		
4	F32T8	2	ELECT DIM	Electronic Dimming (to 1%)	150	(2) two lamp ballasts		
5-foot Fluorescent Rapid Start (40W)								
4	F40T8	1	MAG EE	Magnetic Energy Efficient	50			
2	F40T8	1	MAG EE	Magnetic Energy Efficient	92			
4	F40T8	1	ELECT	Electronic	46			
2	F40T8	1	ELECT	Electronic	79			
3	F40T8	2	ELECT	Electronic	109			
Fluorescent Rapid Start T12 (25, 30, 32, 34W)								

3-foot Fluorescent Rapid Start Energy Saving (25W)						
No.	Lamp	No.	Abbreviation	Description	Watts	Comments
4	F30T12/ES	1	MAG STD	Magnetic Standard	42	
2	F30T12/ES	1	MAG STD	Magnetic Standard	74	
3	F30T12/ES	1.5	MAG STD	Magnetic Standard	111	Tandem wired
3	F30T12/ES	2	MAG STD	Magnetic Standard	116	
2	F30T12/ES	1	MAG EE	Magnetic Energy Efficient	66	
4	F30T12/ES	1	ELECT	Electronic	26	
2	F30T12/ES	1	ELECT	Electronic	53	

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Lamp		Ballast			Watts/ Luminaire	Comments
No.	Designation	No.	Abbreviation	Description		
Fluorescent Rapid Start T12 (25, 30, 32, 34W) (cont.)						
3-foot Fluorescent Rapid Start Standard (30W)						
4	F30T12	1	MAG STD	Magnetic Standard	46	
2	F30T12	1	MAG STD	Magnetic Standard	79	
3	F30T12	1.5	MAG STD	Magnetic Standard	118	Tandem wired
3	F30T12	2	MAG STD	Magnetic Standard	125	
4-foot Fluorescent Rapid Start Energy Saving Plus (32W)						
4	F40T12/ES Plus	0.5	MAG EE	Magnetic Energy Efficient	34	Tandem wired
4	F40T12/ES Plus	1	MAG EE	Magnetic Energy Efficient	41	
2	F40T12/ES Plus	1	MAG EE	Magnetic Energy Efficient	68	
3	F40T12/ES Plus	1	MAG EE	Magnetic Energy Efficient	99	
3	F40T12/ES Plus	1.5	MAG EE	Magnetic Energy Efficient	102	Tandem wired
3	F40T12/ES Plus	2	MAG EE	Magnetic Energy Efficient	109	
4	F40T12/ES Plus	2	MAG EE	Magnetic Energy Efficient	136	(2) Two lamp ballasts
4-foot Fluorescent Rapid Start Energy Saving (34W)						
4	F40T12/ES	0.5	MAG STD**	Magnetic Standard	42	Tandem wired
4	F40T12/ES	1	MAG STD**	Magnetic Standard	48	
2	F40T12/ES	1	MAG STD**	Magnetic Standard	82	
3	F40T12/ES	1.5	MAG STD**	Magnetic Standard	122	Tandem wired

3	F40T12/ES	2	MAG STD**	Magnetic Standard	130	
4	F40T12/ES	2	MAG STD**	Magnetic Standard	164	(2) Two-lamp ballasts
1	F40T12/ES	0.5	MAG EE	Magnetic Energy Efficient	36	Tandem-wired
1	F40T12/ES	1	MAG EE	Magnetic Energy Efficient	43	
2	F40T12/ES	1	MAG EE	Magnetic Energy Efficient	72	
3	F40T12/ES	1	MAG EE	Magnetic Energy Efficient	105	
3	F40T12/ES	1.5	MAG EE	Magnetic Energy Efficient	108	Tandem-wired
3	F40T12/ES	2	MAG EE	Magnetic Energy Efficient	112	
4	F40T12/ES	2	MAG EE	Magnetic Energy Efficient	144	(2) Two-lamp ballasts
2	F40T12/ES	1	MAG HC	Magnetic Heater Cutout	58	
3	F40T12/ES	1.5	MAG HC	Magnetic Heater Cutout	87	Tandem-wired
4	F40T12/ES	2	MAG HC	Magnetic Heater Cutout	116	(2) Two-lamp ballasts
2	F40T12/ES	1	MAG HC FO	Mag. Heater Cutout Full Light	66	
3	F40T12/ES	1.5	MAG HC FO	Mag. Heater Cutout Full Light	99	Tandem-wired
4	F40T12/ES	2	MAG HC FO	Mag. Heater Cutout Full Light	132	(2) Two-lamp ballasts

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Lamp		Ballast			Watts/ Luminaire	
No.	Designation	No.	Abbreviation	Description	Luminaire	Comments
<u>Fluorescent Rapid Start T12 (25, 30, 32, 34W) (cont.)</u>						
4 foot Fluorescent Rapid Start Energy-Saving (34W) (cont.)						
4	F40T12/ES	0.5	ELECT	Electronic	30	Tandem-wired
4	F40T12/ES	1	ELECT	Electronic	34	
2	F40T12/ES	1	ELECT	Electronic	62	
3	F40T12/ES	1	ELECT	Electronic	90	
3	F40T12/ES	1.5	ELECT	Electronic	93	Tandem-wired
3	F40T12/ES	2	ELECT	Electronic	93	
4	F40T12/ES	1	ELECT	Electronic	121	
4	F40T12/ES	2	ELECT	Electronic	124	(2) Two-lamp

						ballasts
2	F40T12/ES	1	ELECT AO	Elec. Adjustable Output (to 15%)	60	
3	F40T12/ES	1.5	ELECT AO	Elec. Adjustable Output (to 15%)	90	Tandem wired
4	F40T12/ES	2	ELECT AO	Elec. Adjustable Output (to 15%)	120	(2) Two-lamp ballasts
Fluorescent Rapid Start T12 (40W)*						
4-foot Fluorescent Rapid Start Standard (40W)						
4	F40T12	0.5	MAG STD**	Magnetic Standard	26	Tandem wired
4	F40T12	1	MAG STD**	Magnetic Standard	52	
2	F40T12	1	MAG STD**	Magnetic Standard	96	
3	F40T12	1.5	MAG STD**	Magnetic Standard	144	Tandem wired
3	F40T12	2	MAG STD**	Magnetic Standard	148	
4	F40T12	2	MAG STD**	Magnetic Standard	192	(2) Two-lamp ballasts
4	F40T12	0.5	MAG EE	Magnetic Energy Efficient	44	Tandem wired
4	F40T12	1	MAG EE	Magnetic Energy Efficient	46	
2	F40T12	1	MAG EE	Magnetic Energy Efficient	88	
3	F40T12	1	MAG EE	Magnetic Energy Efficient	127	
3	F40T12	1.5	MAG EE	Magnetic Energy Efficient	132	Tandem wired
3	F40T12	2	MAG EE	Magnetic Energy Efficient	134	
4	F40T12	2	MAG EE	Magnetic Energy Efficient	176	(2) Two-lamp ballasts
2	F40T12	1	MAG HC	Magnetic Heater Cutout	71	
3	F40T12	1.5	MAG HC	Magnetic Heater Cutout	107	Tandem wired
4	F40T12	2	MAG HC	Magnetic Heater Cutout	142	(2) Two-lamp ballasts

LUMINAIRE POWER**Table B-101**

Lamp		Ballast			Watts/ Luminaire	Comments
No.	Designation	No.	Abbreviation	Description		
Fluorescent Rapid Start T12 (40W)* (cont.)						
4-foot Fluorescent Rapid Start Standard (40W) (cont.)						

2	F40T12	1	MAG HC FO	Magnetic Heater Cutout Full Light	80	
3	F40T12	1.5	MAG HC FO	Magnetic Heater Cutout Full Light	120	Tandem-wired
4	F40T12	2	MAG HC FO	Magnetic Heater Cutout Full Light	160	(2) Two-lamp ballasts
4	F40T12	0.5	ELECT	Electronic	36	Tandem-wired
4	F40T12	1	ELECT	Electronic	37	
2	F40T12	1	ELECT	Electronic	72	
3	F40T12	1	ELECT	Electronic	107	
3	F40T12	1.5	ELECT	Electronic	108	Tandem-wired
3	F40T12	2	ELECT	Electronic	109	
4	F40T12	1	ELECT	Electronic	135	
4	F40T12	2	ELECT	Electronic	144	(2) Two-lamp ballasts
2	F40T12	1	ELECT RO	Electronic Reduce Output (75%)	61	
3	F40T12	1	ELECT RO	Electronic Reduce Output (75%)	90	
3	F40T12	1.5	ELECT RO	Electronic Reduce Output (75%)	92	Tandem-wired
4	F40T12	2	ELECT RO	Electronic Reduce Output (75%)	122	(2) Two-lamp ballasts
2	F40T12	1	ELECT TL	Elec. Two Level (50 & 100%)	69	
3	F40T12	1.5	ELECT TL	Elec. Two Level (50 & 100%)	104	Tandem-wired
4	F40T12	2	ELECT TL	Elec. Two Level (50 & 100%)	138	(2) Two-lamp ballasts
2	F40T12	1	ELECT AO	Elec. Adjustable Output (to 15%)	73	
3	F40T12	1.5	ELECT AO	Elec. Adjustable Output (to 15%)	110	Tandem-wired
4	F40T12	2	ELECT AO	Elec. Adjustable Output (to 15%)	146	(2) Two-lamp ballasts
2	F40T12	1	ELECT DIM	Electronic Dimming (to 1%)	83	
3	F40T12	1.5	ELECT DIM	Electronic Dimming (to 1%)	125	Tandem-wired
4	F40T12	2	ELECT DIM	Electronic Dimming (to 1%)	166	(2) Two-lamp ballasts

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Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments
No.	Designation	No.	Abbreviation	Description		

Fluorescent Rapid Start T10 (42W)*						
4 foot Fluorescent Rapid Start Extended Output (42W)						
2	F40T10/EO	1	MAG EE	Magnetic Energy Efficient	92	
3	F40T10/EO	1.5	MAG EE	Magnetic Energy Efficient	138	Tandem-wired
4	F40T10/EO	2	MAG EE	Magnetic Energy Efficient	184	(2) Two-lamp ballasts
2	F40T10/EO	1	MAG HC	Magnetic Heater Cutout	74	
3	F40T10/EO	1.5	MAG HC	Magnetic Heater Cutout	111	Tandem-wired
4	F40T10/EO	2	MAG HC	Magnetic Heater Cutout	148	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT	Electronic	74	
3	F40T10/EO	1.5	ELECT	Electronic	111	Tandem-wired
4	F40T10/EO	2	ELECT	Electronic	148	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT RO	Electronic Reduce Output (75%)	63	
3	F40T10/EO	1.5	ELECT RO	Electronic Reduce Output (75%)	95	Tandem-wired
4	F40T10/EO	2	ELECT RO	Electronic Reduce Output (75%)	126	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT TL	Elec. Two Level (50 & 100%)	72	
3	F40T10/EO	1.5	ELECT TL	Elec. Two Level (50 & 100%)	108	Tandem-wired
4	F40T10/EO	2	ELECT TL	Elec. Two Level (50 & 100%)	144	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT AO	Elec. Adjustable Output (to 15%)	73	
3	F40T10/EO	1.5	ELECT AO	Elec. Adjustable Output (to 15%)	110	Tandem-wired
4	F40T10/EO	2	ELECT AO	Elec. Adjustable Output (to 15%)	146	(2) Two-lamp ballasts
2	F40T10/EO	1	ELECT DIM	Electronic Dimming (to 1%)	85	
3	F40T10/EO	1.5	ELECT DIM	Electronic Dimming (to 1%)	128	Tandem-wired
4	F40T10/EO	2	ELECT DIM	Electronic Dimming (to 1%)	170	(2) Two-lamp ballasts

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Table B-101

Lamp	Ballast	Watts/

No.	Designation	No.	Abbreviation	Description	Luminaire	Comments
Fluorescent Rapid Start High Output (HO) T8 & T12, 8 ft*						
8 foot Fluorescent Rapid Start High Output Energy Saving (86W)						
2	F96T8/HO	1	ELECT	Electronic	160	
8 foot Fluorescent Rapid Start High Output Energy Saving (95W)						
4	F96T12/HO/ES	1	MAG STD	Magnetic Standard	125	
2	F96T12/HO/ES	1	MAG STD**	Magnetic Standard	227	
2	F96T12/HO/ES	1	MAG EE	Magnetic Energy Efficient	208	
4	F96T12/HO/ES	2	MAG EE	Magnetic Energy Efficient	416	(2) Two-lamp ballasts
2	F96T12/HO/ES	1	ELECT	Electronic	160	
4	F96T12/HO/ES	2	ELECT	Electronic	320	(2) Two-lamp ballasts
8 foot Fluorescent Rapid Start High Output (110W)						
4	F96T12/HO	1	MAG STD	Magnetic Standard	140	
2	F96T12/HO	1	MAG STD**	Magnetic Standard	252	
2	F96T12/HO	1	MAG EE	Magnetic Energy Efficient	237	
4	F96T12/HO	2	MAG EE	Magnetic Energy Efficient	474	(2) Two-lamp ballasts
2	F96T12/HO	1	ELECT	Electronic	190	
4	F96T12/HO	2	ELECT	Electronic	380	(2) Two-lamp ballasts
Fluorescent Rapid Start Very High Output (VHO) T12, 8 ft*						
8 foot Fluorescent Rapid Start Very High Output Energy Saving (195W)						
4	F96T12/VHO/ES	1	MAG STD	Magnetic Standard	200	
2	F96T12/VHO/ES	1	MAG STD	Magnetic Standard	325	
4	F96T12/VHO/ES	2	MAG STD	Magnetic Standard	650	(2) Two-lamp ballasts
8 foot Fluorescent Rapid Start Very High Output (215W)						
4	F96T12/VHO	1	MAG STD	Magnetic Standard	230	
2	F96T12/VHO	1	MAG STD	Magnetic Standard	440	
4	F96T12/VHO	2	MAG STD	Magnetic Standard	880	

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Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Fluorescent Instant Start (single pin base "Slimline") T12, 4 ft								
4 foot Fluorescent Slimline Energy Saving T12 (32W)								
4	F48T12/ES	1	MAG-STD	Magnetic Standard	51			
2	F48T12/ES	1	MAG-STD	Magnetic Standard	82			
4 foot Fluorescent Slimline Standard T12 (39W)								
4	F48T12	1	MAG-STD	Magnetic Standard	59			
2	F48T12	1	MAG-STD	Magnetic Standard	98			
Fluorescent Instant Start (single pin base "Slimline") T8 & T12, 8 ft.								
8 foot Fluorescent Instant Start T8 (Slimline with Rare Earth Phosphors)								
4	F96T8	1	ELECT	Electronic	71			
2	F96T8	1	ELECT	Electronic	115			
8 foot Fluorescent Slimline Energy Saving (60W)								
4	F96T12/ES	1	MAG-STD	Magnetic Standard	83			
2	F96T12/ES	1	MAG-STD**	Magnetic Standard	138			
2	F96T12/ES	1	MAG-EE	Magnetic Energy Efficient	123			
4	F96T12/ES	2	MAG-EE	Magnetic Energy Efficient	246	(2) Two-lamp ballasts		
2	F96T12/ES	1	ELECT	Electronic	105			
4	F96T12/ES	2	ELECT	Electronic	210	(2) Two-lamp ballasts		
8 foot Fluorescent Slimline Standard (75W)								
4	F96T12	1	MAG-STD	Magnetic Standard	100			
2	F96T12	1	MAG-STD**	Magnetic Standard	173			
2	F96T12	1	MAG-EE	Magnetic Energy Efficient	158			
4	F96T12	2	MAG-EE	Magnetic Energy Efficient	316	(2) Two-lamp ballasts		

2	F96T12	1	ELECT	Electronic	130	
4	F96T12	2	ELECT	Electronic	260	(2) Two-lamp ballasts
2	F96T12	1	ELECT IS	Electronic Instant Start	130	
3	F96T12	1.5	ELECT IS	Electronic Instant Start	195	Tandem wired
4	F96T12	2	ELECT IS	Electronic Instant Start	260	(2) Two-lamp ballasts

LUMINAIRE POWER

Table B-101

Lamp		Ballast			Watts/ Luminaire	
No.	Designation	No.	Abbreviation	Description		Comments
High Intensity Discharge						
Mercury Vaper						
4	MV40	1	MAG-STD	Magnetic Standard	51	
4	MV50	1	MAG-STD	Magnetic Standard	63	
4	MV75	1	MAG-STD	Magnetic Standard	88	
4	MV100	1	MAG-STD	Magnetic Standard	119	
4	MV175	1	MAG-STD	Magnetic Standard	197	
4	MV250	1	MAG-STD	Magnetic Standard	285	
4	MV400	1	MAG-STD	Magnetic Standard	450	
4	MV1000	1	MAG-STD	Magnetic Standard	1080	
Metal Halide						
4	MH32	1	MAG-STD	Magnetic Standard	42	
4	MH70	1	MAG-STD	Magnetic Standard	95	
4	MH100	1	MAG-STD	Magnetic Standard	142	
4	MH175	1	MAG-STD	Magnetic Standard	210	
4	MH250	1	MAG-STD	Magnetic Standard	295	
4	MH400	1	MAG-STD	Magnetic Standard	461	
4	MH1000	1	MAG-STD	Magnetic Standard	1080	
High Pressure Sodium						

4	HPS35	1	MAG STD	Magnetic Standard	44
4	HPS50	1	MAG STD	Magnetic Standard	61
4	HPS70	1	MAG STD	Magnetic Standard	93
4	HPS100	1	MAG STD	Magnetic Standard	116
4	HPS150	1	MAG STD	Magnetic Standard	173
4	HPS200	1	MAG STD	Magnetic Standard	240
4	HPS250	1	MAG STD	Magnetic Standard	302
4	HPS400	1	MAG STD	Magnetic Standard	469
4	HPS1000	1	MAG STD	Magnetic Standard	1090
Low Pressure Sodium					
4	LPS18	1	MAG STD	Magnetic Standard	30
4	LPS35	1	MAG STD	Magnetic Standard	60
4	LPS55	1	MAG STD	Magnetic Standard	80
4	LPS90	1	MAG STD	Magnetic Standard	125
4	LPS135	1	MAG STD	Magnetic Standard	178
4	LPS180	1	MAG STD	Magnetic Standard	220

~~LUMINAIRE POWER~~

Table B-101

Lamp		Ballast			Watts/ Luminaire	Comments		
No.	Designation	No.	Abbreviation	Description				
Incandescent Low Voltage Tungsten Halogen								
12-Volt Tungsten Halogen, MR-16 & Electronic Transformer								
4	Q20MR16(12V)	1	ELECT	Electronic	23			
4	Q35MR16(12V)	1	ELECT	Electronic	39			
4	Q50MR16(12V)	1	ELECT	Electronic	55			
4	Q70MR16(12V)	1	ELECT	Electronic	78			

* US Energy Policy Act of 1992 affect on lamps

Beginning in April 1994, many common wattage lamp types can no longer be manufactured or imported into the U.S. Federal Energy Legislation has decreed that these lamp types must be eliminated to reduce energy consumption. Lamp Types affected include the following fluorescent lamps:

	Fluorescent Lamps	F40U/3	Cool White	F96T12/	W
F40	CW	F40U/3	Warm White	F96T12/	WW
F40	D	F40U/6	Cool White	F96T12/	WWX
F40	D/W/M	F40U/6	Warm White Deluxe	F96T12/	WWX/WM
F40	W	F40U/6	Warm White	F96T12/	HO/D
F40	WW	F96T1 2/	CW	F96T12/	HO/CW
F40	WWX	F96T1 2/	D	F96T12/	HO/W
F40	WWX/WM	F96T1 2/	D/W/M	F96T12/	HO/WW

Incandescent PAR Lamps

75PAR38	150PAR38
75/65PAR38	150/120PAR38
100/80PAR38	
100PAR38	

Inc. Reflector Lamps

75R40	200R40
75R30	
150R40	
100R40	

~~** US National Appliance Energy Conservation Act of 1988 affect on ballasts~~

~~In 1991 using the following Standard Magnetic ballasts was not permitted in the US.~~

~~-Single and two lamp ballasts for 4' T12 Rapid Start Lamps, 120V & 277V 60Hz~~

~~-Two lamp ballasts for 8' T-12 Slimline lamps~~

~~-Two lamp ballasts for 8' T12 high output rapid start lamps~~

ACM NC-2005**Appendix NC - Fan Motor Efficiencies**Table NC-1 Fan Motor Efficiencies (< 1 HP)

Nameplate or Brake Horsepower	Standard Fan Motor Efficiency	NEMA* High Efficiency	Premium Efficiency
<u>1/20</u>	<u>40%</u>	...	...
<u>1/12</u>	<u>49%</u>	...	...
<u>1/8</u>	<u>55%</u>	...	...
<u>1/6</u>	<u>60%</u>	...	...
<u>1/4</u>	<u>64%</u>	...	...
<u>1/3</u>	<u>66%</u>	...	...
<u>1/2</u>	<u>70%</u>	<u>76.0%</u>	<u>80.0%</u>
<u>3/4</u>	<u>72%</u>	<u>77.0%</u>	<u>84.0%</u>

NOTE: For default drive efficiencies. See Section 4.2.2*NEMA - Proposed standard using test procedures.Minimum NEMA efficiency per test IEEE 112b Rating Method.

Table NC-2 Fan Motor Efficiencies (1 HP and over)

Motor Horsepower	Open Motors				Enclosed Motors			
	2 pole 3600 rpm	4 pole 1800 rpm	6 pole 1200 rpm	8 pole 900 rpm	2 pole 3600 rpm	4 pole 1800 rpm	6 pole 1200 rpm	8 pole 900 rpm
<u>1</u>	—	82.5	80.0	74.0	75.5	82.5	80.0	74.0
<u>1.5</u>	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
<u>2</u>	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
<u>3</u>	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
<u>5</u>	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
<u>7.5</u>	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
<u>10</u>	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
<u>15</u>	89.5	91.0	92.0	89.5	90.2	91.0	90.2	88.5
<u>20</u>	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
<u>25</u>	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
<u>30</u>	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
<u>40</u>	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0
<u>50</u>	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
<u>60</u>	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
<u>75</u>	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
<u>100</u>	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0
<u>125</u>	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
<u>150</u>	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
<u>200</u>	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
<u>250</u>	94.5	95.0	95.4	94.5	95.4	95.0	95.0	94.5
<u>300</u>	95.0	95.4	95.4	—	95.4	95.4	95.0	—
<u>350</u>	95.0	95.4	95.4	—	95.4	95.4	95.0	—
<u>400</u>	95.4	95.4	—	—	95.4	95.4	—	—
<u>450</u>	95.8	95.8	—	—	95.4	95.4	—	—
<u>500</u>	95.8	95.8	—	—	95.4	95.8	—	—

Appendix C:
Reference Weather/Climate Data

Appendix C: Reference Weather/Climate Data

C.1 Weather Data - General

All energy budget calculations for compliance runs use a form of the weather data in the Commission's official sixteen (16) climate zone hourly weather files. The reference method uses a form of this data that is adjusted for local ASHRAE design data extremes. These files are available from the Commission in the WYEC2 (Weather Year for Energy Calculations) format recognized by ASHRAE and in DOE 2.1E packed weather data format. The reference method computer program for adjusting the climate zone weather data for local ASHRAE design data is also available from the Commission. Temperatures in the WYEC2 files for the sixteen climate zones have been adjusted to the average means and extremes of the weather data of the reliable substations in each climate zone. See *Climate Zone Weather Data Analysis and Revision Project, Final Consultant Report*, CEC Publication # P400-92-004, for more detail.

The WYEC2 data may be adjusted for local conditions, condensed, statistically summarized or otherwise reduced, as long as:

- a) The weather data used to derive the simplified or reduced data is the Commission's official hourly weather data; and,
- b) The ACM program meets all of the certification tests using the reduced weather data.

Whatever weather data and/or weather data reduction methods are used, approval of the ACM for compliance purposes with the standards is contingent upon the fact that approved weather data will be used for all compliance runs. The Commission must be able to verify that the proper weather data is being used by building permit applicants.

The official weather data for energy compliance is available from the Commission in a form suitable for 3.5" high-density IBM PC formatted diskettes. There are 16 climate zones, each with an 8760 hourly records containing raw data on a variety of ambient conditions such as:

- Dry bulb temperature
- Wet bulb temperature
- Wind speed and direction
- Direct solar radiation
- Diffuse radiation

Each climate zone file includes the non-temperature data of a particular city whose annual climate data has been judged representative of the construction locations within that zone. The values listed by climate zone

and the nominal city location for each climate zone in Table C 1 in this section, Section C.1, must be used for any given climate zone if the ACM does not automatically make local city weather adjustments to the files.

As indicated above the reference method uses local city ASHRAE design data to adjust the climate zone weather data. These adjustments customize the temperature data, especially the extremes, to conform to the ASHRAE design data statistics for the city in question. This makes the HVAC sizing and energy calculations more realistic for energy compliance simulations.

Table C 1: California Climate Zone Summary

Climate				
Zone	City	Latitude	Longitude	Elevation
1	Arcata	40.8	124.2	43
2	Santa Rosa	38.4	122.7	164
3	Oakland	37.7	122.2	6
4	Sunnyvale	37.4	122.4	97
5	Santa Maria	34.9	120.4	236
6	Los Angeles AP	33.9	118.5	97
7	San Diego	32.7	117.2	13
8	El Toro	33.6	117.7	383
9	Burbank	34.2	118.4	655
10	Riverside	33.9	117.2	1543
11	Red Bluff	40.2	122.2	342
12	Sacramento	38.5	121.5	17
13	Fresno	36.8	119.7	328
14	China Lake	35.7	117.7	2293
15	El Centro	32.8	115.6	30
16	Mt. Shasta	41.3	122.3	3544

C.2 WYEC2 Climate/Weather Data Format

The ASCII versions of the WYEC2 weather files consist of 8760 identical fixed format records, one for each hour of a 365 day year. Each record is 116 characters in length and is organized according to the format shown in Table C-2 which follows.

The WYEC2 format is derived from the NOAA TD 9734 Typical Meteorological Year (TMY) format in that WYEC2 uses the same field encoding and units as TMY. However, it should be noted that ***all WYEC2 values are for Local Standard Time***. That is, WYEC2 data should be read sequentially and used with no conversion (except any required unit conversions). This is in marked contrast to the TMY files which contain solar data for Apparent Solar Time and meteorological data for Local Standard Time.

Irradiance and illuminance fields contain data integrated over the hour, meteorological fields contain observations made at the end of the hour. For example, hour 12 contains irradiance/illuminance integrated from 11-12 and meteorological observations made at 12.

Table C-2
WYEC DATA FORMAT

TABLE C-2
WYEC2 DATA FORMAT

Field Number	Data Positions	Flag Position (see notes)	Data Element and Description
-001	001-005	—	<p>-WBAN station identification number</p> <p>-Unique number to identify each station</p> <p>-California compliance files contain 00001-00016 in this field to indicate the climate zone</p>
-002	006-006	—	<p>-File source code</p> <p>—W = WYEC</p> <p>—T = TMY</p> <p>—C = California Compliance</p>

-003	007-014	—	<p>Time, Yr Mo Day Hr (2 chars each)</p> <p>Yr omits the "19" and indicates the source year for the data, i.e., 00 = 1900, 99 = 1999. Data within a single WYEC2 file may have been observed in more than one year.</p> <p>Mo is 1 to 12.</p> <p>Day is 1 to month length (28, 30, or 31).</p> <p>Hr is 1 to 24.</p>
-101	015-018	—	<p>Extraterrestrial irradiance, kJ/m²</p> <p>Amount of solar energy received at top of atmosphere during solar hour ending at time indicated in field 003, based on solar constant of 1367 kJ/m².</p> <p>Nightime values are shown as 0.</p>
-102	019-022	023-024	<p>Global horizontal irradiance, kJ/m²</p> <p>Total of direct and diffuse radiant energy received on a horizontal surface by a pyranometer during the hour ending at the time indicated in field 003.</p>
-103	025-028	029-030	<p>Direct normal irradiance, kJ/m²</p> <p>Portion of the radiant energy received at the pyrheliometer directly from the sun during the hour ending at the time indicated in field 003.</p>
-104	031-034	035-036	<p>Diffuse horizontal irradiance, kJ/m²</p> <p>Amount of radiant energy in kJ/m² received at the instrument indirectly from the sky during the hour ending at the time indicated in field 003.</p>
-105	037-040	041	<p>Global horizontal illuminance, lux * 100</p>
-106	042-045	046	<p>Direct normal illuminance, lux * 100</p>
-107	047-050	051	<p>Diffuse horizontal illuminance, lux * 100</p>

-108	052-055	056	Zenith luminance, Cd/m² * 100
-110	057-058	059	Minutes of sunshine, 0 - 60 minutes
-201	060-063	064	<p>Ceiling Height, m * 10</p> <p>Ceiling is defined as opaque sky cover of 0.6 or greater.</p> <p>—0000—3000 = 0 to 30,000 m</p> <p>—7777 = unlimited; clear</p> <p>—8888 = unknown height of cirroform ceiling</p>
-202	065-068	069	<p>Sky Condition</p> <p>All observations assumed to be made after 1 June 1951. ("indicator" at position 77 in TMY is omitted).</p> <p>Coded by layer in ascending order; four layers are described; if less than 4 layers are present the remaining positions are coded 0. The code for each layer is:</p> <p>—0 = Clear of less than 0.1 cover</p> <p>—1 = Thin scattered (0.1—0.5 cover)</p> <p>—2 = Opaque scattered (0.1—0.5 cover)</p> <p>—3 = Thin broken (0.6—0.9 cover)</p> <p>—4 = Opaque broken (0.6—0.9 cover)</p> <p>—5 = Thin overcast (1.0 cover)</p> <p>—6 = Opaque overcast (1.0 cover)</p>

			<p>7 = Obscuration</p> <p>8 = Partial obscuration</p>
203	070-073	074	<p>Visibility, m * 100</p> <p>Prevailing horizontal visibility.</p> <p>—0000-1600 = 0 to 160 kilometers</p> <p>—8888 = unlimited</p>
204	-075-082	083	<p>Weather</p> <p>Eight single digit codes as follows:</p>
204 (cont.)	-075		<p>Occurrence of thunderstorm, tornado or squall.</p> <p>—0 = None</p> <p>—1 = Thunderstorm — lightning and thunder. Wind gusts less than 50 knots, and hail, if any, less than 3/4 inch diameter.</p> <p>—2 = Heavy or severe thunderstorm — frequent intense lightning and thunder. Wind gusts 50 knots or greater and hail, if any, 3/4 inch or greater diameter.</p> <p>—3 = Report of tornado or waterspout.</p> <p>—4 = Squall (sudden increase of wind speed by at least 16 knots, reach 22 knots or more and lasting for at least</p>

		<p>one minute).</p>
-204 (cont.)	-076	<p>Occurrence of rain, rain showers or freezing rain:</p> <p>—0 = None</p> <p>—1 = Light rain</p> <p>—2 = Moderate rain</p> <p>—3 = Heavy rain</p> <p>—4 = Light rain showers</p> <p>—5 = Moderate rain showers</p> <p>—6 = Heavy rain showers</p> <p>—7 = Light freezing rain</p> <p>—8 = Moderate or heavy freezing rain</p>
-204 (cont.)	-077	<p>Occurrence of drizzle, freezing drizzle</p> <p>—0 = None</p> <p>—1 = Light drizzle</p> <p>—2 = Moderate drizzle</p>

		<p>-3 = Heavy drizzle</p> <p>-4 = Light freezing drizzle</p> <p>-5 = Moderate freezing drizzle</p> <p>-6 = Heavy freezing drizzle</p>
-204 (cont.)	-078	<p>Occurrence of snow, snow pellets or ice crystals</p> <p>-0 = None</p> <p>-1 = Light snow</p> <p>-2 = Moderate snow</p> <p>-3 = Heavy snow</p> <p>-4 = Light snow pellets</p> <p>-5 = Moderate snow pellets</p> <p>-6 = Heavy snow pellets</p> <p>-7 = Light ice crystals</p> <p>-8 = Moderate ice crystals</p> <p>Beginning April 1963 intensities of ice crystals were discontinued.</p> <p>All occurrences since this date are recorded as an 8.</p>
-204 (cont.)	-079	<p>Occurrence of snow showers or snow grains</p> <p>-0 = None</p> <p>-1 = Light snow showers</p>

		<p>—2 = Moderate snow showers</p> <p>—3 = Heavy snow showers</p> <p>—4 = Light snow grains</p> <p>—5 = Moderate snow grains</p> <p>—6 = Heavy snow grains</p> <p>Beginning April 1963 intensities of snow grains were discontinued.</p> <p>All occurrences since this date are recorded as a 5.</p>
-204 (cont.)	-080	<p>Occurrence of sleet (ice pellets), sleet showers or hail</p> <p>—0 = None</p> <p>—1 = Light sleet or sleet showers (ice pellets)</p> <p>—2 = Moderate sleet or sleet showers (ice pellets)</p> <p>—3 = Heavy sleet or sleet showers (ice pellets)</p> <p>—4 = Light hail</p> <p>—5 = Moderate hail</p> <p>—6 = Heavy hail</p> <p>—7 = Light small hail</p> <p>—8 = Moderate or heavy small hail</p> <p>Prior to April 1970 ice pellets were coded as sleet. Beginning April 1970 sleet and small hail were redefined as ice pellets and are coded as a 1, 2, or 3 in this position. Beginning September 1956 intensities of hail were no longer reported and all occurrences were recorded as a 5.</p>

-204 (cont.)	-081	<p>Occurrence of fog, blowing dust or blowing sand</p> <p>-0 = None</p> <p>-1 = Fog</p> <p>-2 = Ice Fog</p> <p>-3 = Ground Fog</p> <p>-4 = Blowing dust</p> <p>-5 = Blowing sand</p> <p>These values recorded only when visibility less than 7 miles.</p>
-204 (cont.)	-082	<p>Occurrence of smoke, haze, dust, blowing snow or blowing spray:</p> <p>-0 = None</p> <p>-1 = Smoke</p> <p>-2 = Haze</p> <p>-3 = Smoke and haze</p> <p>-4 = Dust</p> <p>-5 = Blowing snow</p> <p>-6 = Blowing spray</p> <p>These values recorded only when visibility less than 7 miles.</p>

-205	-084-088	-089	Station pressure, kilopascals (kPa) * 100 Pressure at station level —08000—10999 = 80 to 109.99 kPa.
-206	-090-093	-094	Dry bulb temperature, °C * 10 —700 to 0600 = -70.0 to +60.0 °C
-207	-095-098	-099	Dew point, °C * 10 —700 to 0600 = -70.0 to +60.0 °C
-208	-100-102	-103	Wind direction, 0—359 degrees —0 = north Note TMY range is 0—360, WYEC2 has recoded 360 as 0.
-209	-104-107	-108	Wind speed, m/s * 10 —0—1500 = 0 to 150.0 m/s. Wind speed and wind direction both 0 indicates calm.
-210	-109-110	-111	Total Sky Cover, 0—10 in tenths Amount of celestial dome in tenths covered by clouds or obscuring phenomena.
-211	-112-113	-114	Opaque Sky Cover, 0—10 in tenths Amount of celestial dome in tenths covered by clouds or obscuration through which the sky and/or higher cloud layers cannot be seen.
-212	-115-115	-116	Snow Cover —0 = no snow or a trace of snow —1 = indicates more than a trace of snow on the ground

Notes for Table C-2 – WYEC2 Format:

1. Total file size (including CRLFs) = 118 x 8,760 = 1,033,680 characters.

2. Flag characters indicate the source of the associated value and, in the case of solar fields, optionally give information about the quality of the value.

Some fields have no flag, others have 1 or 2 character flags as follows:

Field Flag type / comment

001 – 003 None (record identification fields)

101 None (calculated extraterrestrial irradiance is always present)

102 – 1042 character (irradiance values)

105 – 2121 character (all remaining fields)

One character flags are alphabetic (with the exception of 9 for missing) and are defined as follows:

(blank) Value was observed (that is, not derived with a model and not altered.)

A Value has been algorithmically adjusted (e.g., dry bulb temperatures were shifted to match long term means).

E Value was missing and has been replaced by a hand estimate.

F Value was bad and has been replaced by a hand estimate.

I Value was missing and has been replaced with one derived by interpolation from neighboring observations.

J Value was bad and has been replaced with one derived by interpolation from neighboring observations.

M _____ Value was missing and has been replaced with one derived with a model
(model used depends on element).

N _____ Value was bad and has been replaced with one derived with a model (model
used depends on element).

P _____ Value violated a physical limit and has been replaced by that limit.

Q _____ Value is derived from other values (e.g., illuminance data which were not
observed).

9 _____ Value is missing; data positions contain 9s as well.

Two character flags (on irradiance fields 102, 103, and 104) are either:

A 1 _____ character flag (as defined above) followed by a blank, or

A 2 _____ character numeric value in the range 00 to 99 and are defined in *SERI Standard
Broadband Format 2*, as follows:

00 _____ Element is untested (original data)

01-03 _____ Element passed tests on physical limits, model limits (for tolerances less than
3%), and reasonable coupling to other parameters (for tolerances less than 3%).

04 _____ Element passed hand/eye tests.

05 _____ Element failed hand/eye tests and has not been corrected.

06 _____ Element was missing and has not been replaced with an estimate.

07 _____ Element's value is lower than a physical limit.

08 _____ Element's value is higher than a physical limit.

09 _____ Element's value is inconsistent with other components (e.g. direct not
consistent with global)

—10-93 Element exceeded the 3% tolerance in one of four ways. The following error types are defined:

0 = too low by 3 parameter coupling

1 = too high by 3 parameter coupling

2 = too low by 2D boundary comparison

3 = too high by 2D boundary comparison

The flags in this range are constructed in such a way that both the percentage of error and the type of error are encoded in the two digit flag. To create the flag, one multiplies the percentage of disagreement by 4, subtract 2, and add the error type. The percentage of error should be truncated—only the integer part is used.

The particular error is determined by the remainder of MOD(IQC - 2 / 4), where "MOD0" is a mathematical function representing the remainder of the quantity (IQC + 2)/4 and "IQC" is the two digit flag number. The percentage error is determined by

$$\text{IPCT} = \text{Int}((\text{IQC} + 2) / 4)$$

IPCT = 23 indicates an error greater than 23%.

94-97 KN = KT + ERR

FLAG ERR

94 5% ETR <= ERR < 10% ETR

95 10% ETR <= ERR < 15% ETR

96 15% ETR <= ERR < 20% ETR

97 20% ETR <= ERR

99 Element is missing or null.

~~It should be noted that the 2-character numeric flags are appropriate for encoding the results of quality control processing of archival solar data. The 1-character alphabetic flags are appropriate for "best estimate" data sets in which any questionable values have been replaced. most WYEC2 files used for engineering purposes will fall into the latter category and will thus use the alphabetic flags on solar fields.~~

~~3. Missing elements are 9 filled: all data and flag positions contain 9s.~~

~~4. Conversion factors relevant to WYEC2 use:~~

<u>To convert from</u>	<u>to</u>	<u>multiply by</u>
kJ/m²	Btu/ft²	0.08807
m/s * 10	mph	0.2273
kPai	n. Hg.	0.002953
m * 10	ft	32.808
m * 100 miles	miles	0.06214

C.3 Climate/Weather Data Adjustments for Local Conditions

This appendix section describes the official procedure used by the California Energy Commission to adjust the Title 24 climate zone data for the sixteen (16) climate zones to match the ASHRAE design day conditions for a specific city.¹ Computer software available from the California Energy Commission takes weather data from one of the sixteen climate zones and uses ASHRAE design data for a specific city within that climate zone to create weather data in the format required by the DOE-2 building simulation program.² The generated weather data has the latitude, longitude, elevation and air properties of a particular city instead of the climate zone's designated weather station indicated in Table D-3. This procedure only modifies the weather data on the climate zone data file to match a city's design conditions for the days which fall within the ASHRAE summer and winter design day percentage levels. However, the entire data set is adjusted to reflect the city's elevation. This city-specific data into DOE-2 allows the program's Heating Ventilation and Air Conditioning (HVAC) sizing procedures to use design conditions closer to the simulated building's actual location. This section outlines the procedure used to incorporate a city's design day data into an hourly climate zone data set.

BACKGROUND

The California Energy Commission, in developing and implementing the Title 24 building energy efficiency standards, has defined sixteen zones that encompass the diversity of California's climatic regions. Each climate zone's hourly weather data set has been derived, predominantly, from a single weather station. Past work sponsored by the Commission modified these data sets to reflect the weather conditions of specific geographic areas within certain climate zones where high levels of building construction were anticipated. This modified Title 24 climate zone data, however, does not represent the particular climatic conditions of any individual city or a specific building site but rather the climate zone as a whole. The weather adjustments described below are intended to increase a compliance program's ability to properly size and simulate HVAC systems.

DEFINITIONS

CITY One of the California cities listed in ASHRAE's CLIMATIC DATA FOR REGION X

TAPE Hourly data which describes the regional weather patterns for one of the 16 California climate zones

RH Relative Humidity (%)

~~DB~~ Dry Bulb temperature ($^{\circ}$ F)

~~WB~~ Wet Bulb temperature ($^{\circ}$ F)

~~P~~ Pressure (psia)

~~MIN~~ Minimum Daily Dry Bulb Temperature ($^{\circ}$ F)

~~MAX~~ Maximum Daily Dry Bulb Temperature ($^{\circ}$ F)

~~Avg~~ Average Daily Dry Bulb Temperature ($^{\circ}$ F)

$$= \text{MAX} - \text{MIN} / 2$$

~~RANGE~~ Daily Dry Bulb Temperature Range ($^{\circ}$ F)

$$= (\text{MAX} - \text{MIN})$$

~~RH RATIO~~ The Daily Ratio of RH_{MAX} for the CITY to RH_{MAX} for the TAPE

~~ODR~~ Outdoor Daily Range ($^{\circ}$ F) as defined by ASHRAE: the difference between the average maximum and average minimum temperature for the warmest month

~~F~~ An hourly temperature function derived from the TAPE

$$= (\text{DB}_{\text{HR}} - \text{AVG}) / \text{RANGE}$$

METHODOLOGY

First, the climate zone design conditions as specified by ASHRAE are computed from the TAPE. The maximum DB is also found off the TAPE. The CITY maximum DB is computed as:

$$\text{CITY}_{\text{max DB}} = \text{TAPE}_{\text{max DB}} * \text{CITY}_{0.1\% \text{ DB}} / \text{TAPE}_{0.1\% \text{ DB}} \quad [1]$$

The psychrometric equations are used to derive RH for the TAPE design conditions³. The atmospheric pressure is adjusted for the CITY elevation, then RH is computed for the CITY design conditions. The form of equation [1] is used to derive the CITY maximum RH, using the TAPE maximum RH and the RH values computed for the TAPE and the CITY at the 0.1% DB conditions.

For each day of the year the following steps are completed:

- 1 MAX, Min, AVG, RANGE, WB_{MAX} and RH_{MAX} are determined for the TAPE,
- 2 A mapping procedure, delineated in Figure 1, is used to find RH_{MAX} for the CITY from the CITY RH design values, the TAPE DB design values and MAX for the TAPE,
- 3 RH_{MAX} and RH RATIO are determined for the CITY. The RH RATIO is set to 1 for all days with MAX less than the CITY 2.0% maximum DB, which equates the RH of the CITY to the RH of the TAPE for all non-design days,
- 4 MAX and MIN for the CITY are computed using mapping procedures similar to that illustrated in Figure 1, from the CITY DB design conditions, the TAPE DB design conditions and MAX/MIN for the TAPE,
- 5 MAX and MIN for the CITY are corrected for the CITY elevation⁴,
- 6 RANGE is calculated for the CITY. RANGE is adjusted by the ratio of the ODR for the CITY to the ODR of the TAPE if MAX is greater than the CITY 2.0% maximum DB,
- 7 AVG for the CITY is calculated in one of three ways:

- (a) AVG = MAX - 5.0 * RANGE,
if MAX > CITY 2.0% maximum DB, or
- (b) AVG = MIN + 0.5 * RANGE,
if MIN < CITY 0.6% minimum DB, or
- (c) AVG = (MAX + MIN) / 2.

Once the daily CITY statistics are computed, they can be applied to the hourly TAPE to generate an hourly CITY weather data set. For each hour of the year, the following steps are completed.

- 1 F is calculated from the Tape,
- 2 P is corrected for CITY elevation,
- 3 RH is calculated for the TAPE,
- 4 RH for the CITY is derived by applying the RH RATIO to the RH for the TAPE,
- 5 DB for the CITY is computed: DB = AVG + F * RANGE,

~~6.WB is calculated using the new values for RH, DB and P for the CITY.~~

~~Upon completion of all weather adjustments the resulting data set is converted to the binary format required by the DOE 2 simulation program.~~

RESULTS

~~An example of the hourly weather adjustments from a TAPE to a CITY is displayed in figure 2. Four summer days are extracted from both the climate zone 16 data (Mt. Shasta) and the city specific data (Tahoe City). The first day plotted falls below the design day threshold; the next three days plotted are design days. The figure depicts the expected downshift of hourly temperatures from Mt. Shasta (maximum DB = 96° F) to Tahoe City (maximum DB = 87° F).~~

SOFTWARE PACKAGE

~~To obtain the software used to adjust DOE 2 files to local design conditions for 641 California cities that is described in this section of Appendix D write to:~~

***LOCAL WEATHER SOFTWARE
EFFICIENCY TECHNOLOGY OFFICE
CALIFORNIA ENERGY COMMISSION
1516 NINTH ST., MS-42
SACRAMENTO, CA 95814-5512***

~~You must include a self addressed, stamped diskette mailer and a preformatted 1.4~~

NOTES for SECTION C.3

1. ASHRAE Publication SPCDX, CLIMATIC DATA FOR REGION X: ARIZONA, CALIFORNIA, HAWAII, NEVADA, defines a city's design day conditions as the ambient dry bulb and wet bulb temperatures which are percentage levels of hours on an annual basis. Summer values are presented for the 0.1%, 0.5% and 2.0% of the annual maximum dry bulb temperature; Winter values are presented for the median, the 0.2% and 0.6% of the annual minimum dry bulb temperature. This publication lists design day data for 641 California cities.
2. The computer software described herein produces two output files. The first file is the hourly weather data in binary DOE 2 format. To produce this file staff has incorporated a program created by Jeff Hirsch (James J. Hirsch and Associates) which converts an ASCII data file into the packed DOE 2 file format. This

~~file is compatible with the DOE 2 program compiled and distributed by James J. Hirsch and Associates as well as several other PC versions of DOE 2. The second file produced is an ASCII file that contains building location data as well as specific design data required by the CEC's nonresidential Alternative Calculation Method (ACM) procedures.~~

- ~~3. The mathematical equations which describe the thermodynamic properties of moist air are published in the ASHRAE HANDBOOK FUNDAMENTALS Volume, PSYCHROMETRICS Chapter. The relative humidity (RH) which corresponds to specific dry bulb and wet bulb temperatures is derived by these principles of psychrometrics throughout this weather adjustment procedure.~~
- ~~4. Elevation adjustments to dry bulb temperature and pressure are made using the standard atmospheric data published in the ASHRAE FUNDAMENTALS Volume, PSYCHOMETRIC Chapter.~~

C.4 California City Design Weather Data

~~The data contained in the multi page Table C 3 was obtained through a joint effort by the Southern California Chapter and the Golden Gate Chapter of ASHRAE. It is reprinted here with the expressed written permission of Southern California Chapter ASHRAE, Inc.~~

~~A full listing of design weather data for California cities is contained in the ASHRAE publication *SPCDX, Climatic Data for Region X: Arizona, California, Hawaii, Nevada* (May, 1982). The publication may be ordered from:~~

~~Order Desk~~

~~Building News~~

~~3055 Overland Avenue~~

~~Los Angeles, CA 90034~~

~~(800) 873-6397 or (213) 202-7775~~

~~Cost: \$17.50 + tax + \$4.25 shipping and handling~~

KEY TO ABBREVIATIONS	
for City Climate Design Data	
Abbreviation	Meaning
AFB	Air Force Base
AFS	Air Force Station
AP	Airport
CO	City/County Office
FD	Fire Department
FS	Fire Station
MCB	Marine Corp. Base
NAS	Naval Air Station
NM	National Monument
PH	Power House
RS	Ranger Station

City	County	Climate Zone	Latitude	Longitude	Elevation		SUMMER								Winter Median of Extremes	HDD*
							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Adelante	San Bernardino	14	34.6		2865	105	67	101	65	97	62	39	14			
Adin RS	Mendocino	16	41.20	120.95	4195	96	61	92	60	88	59	43	7			
Agora Hills	Los Angeles	9	34.2		700	103	70	96	68	90	66	29	27			
Alameda-NAS	Alameda	3	37.70	122.32	15	88	65	82	64	76	62	24	35	2507		
Alamo	Contra Costa	12	37.90	122.92	410	102	69	97	68	92	66	30	23			
Albany	Alameda	3	37.90	122.25	40	88	65	83	64	77	62	16	30			
Alderpoint	Humboldt	2	40.20	123.62	460	100	69	95	67	90	65	39	21	3424		
Alhambra	Los Angeles	9	34		483	100	71	96	70	90	68	25	30			
Aliso Viejo	Orange	8	33.6		50	91	69	83	68	76	66	18	30			
Almaden AFS	Santa Clara	3	37.20	121.00	3470	95	62	90	60	85	59	20	20	4468		
Alondra Park	Los Angeles	6	33.90		50	91	69	86	68	84	66	17	35			
Alpine	San Diego	10	32.70	116.77	1735	99	69	95	68	94	67	35	27			
Alta Sierra	Kern	16	35.7		6500	87	62	84	64	80	59	32	4			
Altadena	Los Angeles	9	34.20		1200	99	68	94	67	88	66	34	32	1920		
Alturas RS	Mendocino	16	41.5	120.55	4400	99	62	96	61	94	59	43	10	6895		
Alum Rock	Santa Clara	4	37.40	121.83	70	95	68	90	66	84	64	22	28			
American Canyon	Napa	2	37.6		85	93	67	90	66	84	64	23	28			
Anaheim	Orange	8	33.70		158	99	69	92	68	85	67	26	32			
Anderson	Shasta	14	40.5	122.25	430	107	71	103	70	97	68	30	26			
Angevin	Napa	2	38.59	122.42	1815	98	66	93	64	88	62	33	25			
Antioch	Contra Costa	12	38	121.77	60	102	70	97	68	94	66	34	22	2627		
Apple Valley	San Bernardino	14	34.5		2935	105	66	101	65	97	64	38	14			
Aptos	Santa Cruz	3	37		500	94	67	88	66	83	63	30	27			
Arcadia	Los Angeles	9	34.20		475	100	69	96	68	91	67	30	31			
Arcata	Humboldt	1	41	124.10	218	75	61	69	59	65	58	11	28	5029		
Arden	Sacramento	12	38.5		80	104	70	100	69	94	67	35	28			
Arroyo Grande	San Luis Obispo	5	35.09		105	92	66	86	64	79	62	18	28			
Artesia	Los Angeles	8	33.70		50	99	71	94	70	85	68	23	33			
Arvin	Kern	13	35.20		445	106	71	102	69	98	68	30	26			
Ash Mtn	Tulare	13	36.5	118.83	1708	105	69	101	68	97	66	30	25	2703		
Ashland	Alameda	3	37.7		45	92	66	86	65	84	62	24	26			
Atascadero	San Luis Obispo	4	35.5	120.70	837	94	66	89	67	84	65	42	25			
Atherton	San Mateo	3	37.5	122.23	50	90	66	84	64	78	62	27	23			
Atwater	Merced	12	37.29		150	102	72	99	70	94	67	38	24			
Auberry	Fresno	13	37.09	119.50	2140	102	69	98	67	95	64	36	24	3313		
Auburn	Placer	14	38.90	121.07	1292	103	69	100	67	95	66	33	25	3089		
Avalon	Los Angeles	6	33.40	118.32	25	83	64	75	62	69	60	11	37	2204		
Avenal	Kings	13	36		550	103	70	98	70	93	69	34	23			
Avocado Heights	Los Angeles	16	34.2		550	101	69	97	68	94	68	30	28			
Azusa	Los Angeles	9	34.09	118.15	605	101	70	97	69	91	68	36	31			
Baker	San Bernardino	14	35.29	116.10	940	115	73	112	72	108	70	29	23			
Bakersfield AP	Kern	13	35.40	119.05	475	106	71	102	70	98	68	34	26	2185		
Balch PH	San Bernardino	14	36.90		1720	100	67	97	66	93	64	26	26			
Baldwin Park	Los Angeles	9	34		394	100	69	96	69	90	68	32	34			
Banning	Riverside	15	33.90	116.88	2349	104	69	100	68	96	67	34	20			
Barrett-Dam	San Diego	10	32.70	116.67	1623	103	69	97	68	92	67	35	22	2656		
Barstow	San Bernardino	14	34.00	117.03	2162	107	69	104	69	100	67	35	16	2580		
Baywood-Los Osos	San Luis Obispo	5	35.3		100	88	65	82	64	76	62	14	34			
Beale AFB	Yuba	14	39.09	121.43	113	105	71	102	70	97	68	34	25	2835		
Beaumont	Riverside	10	33.90	116.97	2605	103	68	99	67	95	66	38	22	2628		

City	County	Climate Zone	Latitude	Longitude	Elevation		SUMMER								Winter Median of Extremes	HDD*
							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Bell	Los Angeles	8	33.90		143	97	70	94	69	85	67	22	33			
Bell Gardens	Los Angeles	8	33.90		160	97	70	94	69	78	62	24	29			
Bellflower	Los Angeles	8	33.79		73	98	70	94	69	85	67	24	32			
Belmont	San Mateo	3	37.5		33	90	66	84	64	78	62	24	29			
Ben Lomond	Santa Cruz	3	37.09	122.10	450	92	67	85	66	79	63	30	25			
Benicia	Solano	12	38.09	122.10	55	99	69	93	67	87	65	30	28			
Berkeley	Alameda	3	37.90	122.25	345	90	64	83	63	76	64	16	33	2950		
Berryessa Lake	Napa	2	38.59	122.05	480	102	70	98	69	92	67	35	26			
Beverly Hills	Los Angeles	9	34.09	118.17	268	94	69	88	68	83	66	20	39			
Big Bar RS	Trinity	16	40.79	121.80	1260	102	68	98	67	93	65	46	19			
Big Bear Lake	San Bernardino	16	34.20	116.88	6745	87	59	83	58	79	56	32	3	6850		
Bishop AP	Inyo	16	37.40	118.37	4108	103	61	100	60	97	58	40	5	4313		
Blackhawk	Contra Costa	12	37.7		40	88	65	82	64	76	62	24	35			
Blackwells Corner	Kern	13	35.59	119.90	644	99	68	94	66	89	65	34	23			
Bloomington	San Bernardino	10	34		980	106	71	102	70	98	69	34	30			
Blue Canyon AP	Placer	16	39.29	120.70	5280	88	60	85	59	84	57	20	13	5704		
Blythe AP	Riverside	15	33.59	114.72	395	115	74	112	73	108	74	27	28	1219		
Blythe CO	Riverside	15	33.59	114.60	268	115	74	112	73	108	74	27	24	1312		
Boca	Nevada	16	39.40	120.10	5575	92	58	89	57	84	55	46	-18	8340		
Bodie	Mono	16	38.20	119.02	8370	83	50	80	49	76	48	42	-24			
Bonadella Ranches -	Fresno	13	36.8		270	105	72	101	70	96	68	40	24			
Benita	Madera	13	32.70	117.03	405	94	69	82	67	78	64	20	28	1864		
Boron AFS	Kern	14	35.09	117.58	3015	106	70	103	69	98	68	35	18	3000		
Borrego Desert PK	San Diego	15	33.20	116.40	805	112	76	107	74	101	72	36	25			
Bostonia	San Diego	10	32.8		600	96	70	94	69	81	67	30	29			
Boulder Creek	Santa Cruz	3	37.2		403	92	67	85	65	79	63	30	25			
Bowman Dam	Placer	14	39.40	120.65	5347	89	59	86	57	82	55	26	9	5964		
Boyes Hot Spgs	Sonoma	2	38.2		300	100	70	95	69	89	67	40	22			
Brannan Island	Sacramento	12	38.09	121.70	30	100	69	95	68	89	67	10	24			
Brawley 2-SW	Imperial	15	33	115.55	100	113	74	110	73	105	73	32	25	1204		
Brea Dam	Orange	8	33.90		275	100	69	94	68	86	66	29	30			
Brentwood	Contra Costa	12	37.9		71	102	70	97	68	89	65	34	27			
Bridgeport	Mono	16	38.20	119.22	6470	89	56	86	54	82	53	41	20			
Broderick Bryte	Yolo	12	38.59	121.50	20	104	71	100	69	94	67	36	25			
Brooks Ranch	Yolo	12	38.79	122.15	294	104	71	99	70	93	68	35	19	2968		
Buena Park	Orange	8	33.90		75	98	69	92	68	85	67	25	31			
Burbank AP	Los Angeles	9	34.20	118.35	699	101	70	96	68	90	67	28	29	1701		
Burbank Vly Pump	Los Angeles	9	34.20	118.35	655	101	69	96	68	90	66	28	29	1678		
Burlingame	San Mateo	3	37.59	122.35	10	88	67	82	64	76	63	20	30			
Burney	Shasta	16	40.90	121.67	3127	95	64	92	63	88	64	42	0	6404		
Butler Valley (Korbel)	Humboldt	1	40.7	123.93	420	91	66	86	64	81	62	22	20			
Buttonwillow	Kern	13	35.40	119.47	269	103	71	99	70	95	68	36	20	2621		
Cabrillo NM	San Diego	7	32.70	117.23	410	89	69	84	68	80	67	12	39			
Cachuma Lake	Santa Barbara	5	34.59	119.98	784	97	69	92	67	87	65	19	26			
Calabasas	Los Angeles	9	34.20		1100	102	71	98	70	93	69	26	26	2348		
Galaveras Big Trees	San Joaquin	12	38.20	120.32	4696	92	61	88	60	84	58	33	11	5848		
Calexico	Imperial	15	32.70		12	114	74	110	73	106	71	28	26			
California City	Kern	14	35.4		2400	107	69	104	68	99	66	33	10			
Callahan	Siskiyou	16	41.29	122.80	3185	97	63	93	62	88	60	35	7			

City	County	Climate Zone	Latitude	Longitude	Elevation		SUMMER								Wind of Median Extr eme	HDD*
							0.1% Dry Bulb	0.1 % Wet Bulb	0.5% Dry Bulb	0.5 % Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Dail y Ran ge			
Galwa	Fresno	13	36.79		330	105	73	101	71	97	68	34	23			
Gamarillo	Ventura	6	34.20	119.20	147	91	69	84	68	78	67	22	28			
Gambria AFS	San Luis Obispo	5	35.5	121.07	600	78	62	72	64	66	59	16	30	3646		
Cameron Park	El Dorado	12	38.6		1800	101	67	98	66	93	65	42	20			
Camp Pardee	Calaveras	12	38.20	120.85	658	106	71	103	70	98	69	36	27	2812		
Camp Pendleton	San Diego	10	33.4		50	88	69	85	68	80	67	12	34			
Camp Roberts	Monterey	4	35.79	120.75	765	106	72	101	71	95	69	45	16	2890		
Campbell	Santa Clara	4	37.29	121.83	195	93	69	88	66	83	65	30	28			
Campe	San Diego	14	32.59	116.47	2630	101	67	95	66	90	66	41	16	3303		
Ganooga Park	Los Angeles	9	34.20	118.57	790	104	71	99	70	93	69	38	25	1884		
Gantil	Kern	14	35.29	117.97	2010	111	71	107	71	103	70	32	12			
Canyon Dam	Plumas	16	40.09	121.08	4555	93	60	90	59	85	57	39	4	6834		
Canyon Lake	Riverside	10	33.8		1500	105	70	101	69	97	68	39	22			
Capitola	Santa Cruz	3	37		64	94	67	88	66	84	63	24	27			
Cardiff by the Sea	San Diego	7	33		80	87	68	83	67	77	65	12	35			
Carlsbad	San Diego	7	33.20		44	87	68	83	67	77	65	10	34			
Carmel Valley	Monterey	3	36.5	121.73	425	94	68	88	66	80	65	20	25			
Carmel-by-the-Sea	Monterey	3	36.5		20	87	65	78	62	74	64	20	30			
Carmichael	Sacramento	12	38.59	121.45	100	104	70	100	69	94	68	35	25			
Carpinteria	Santa Barbara	6	34.40		385	90	69	83	67	77	65	15	30			
Carson	Los Angeles	6	33.79		60	96	69	88	68	82	66	19	33			
Casa de Oro Mount	San Diego	10	32.7		530	96	71	88	69	84	67	19	34			
Castle AFB	Merced	12	37.40	120.57	188	105	71	101	70	96	69	33	24	2590		
Gastro Valley	Alameda	3	37.59	122.20	177	93	67	87	67	80	65	25	24			
Gastrovile	Monterey	3	36.8		20	86	66	77	63	70	64	18	32			
Cathedral City	Riverside	15	33.8		400	117	74	113	73	109	72	33	26			
Catheve Valley	Mariptosa	12	37.40	120.05	1000	102	69	99	68	94	67	38	24			
Cecilville	Siskiyou	16	41.09	123.13	3000	95	63	89	62	84	59	44	13			
Cedarville	Modoc	16	41.5	120.17	4670	97	64	94	60	89	58	35	4	6304		
Centerville PH	Butte	14	39.79	121.67	522	105	70	100	68	96	67	40	25	2895		
Geres	Stanislaus	12	37.59		90	101	72	96	70	90	67	36	24			
Gerritos	Los Angeles	8	33.90		34	99	71	92	69	85	68	23	33			
Charter Oak	Los Angeles	9	34.1		600	101	70	97	69	91	68	34	29			
Chatsworth	Los Angeles	9	34.2		964	98	69	93	68	87	66	38	26			
Cherry Valley Dam	Tuolumne	10	38		4765	96	62	92	64	88	59	32	9			
Cherryland	Alameda	3	37.5		100	93	67	86	66	79	64	24	26			
Chester	Plumas	16	40.29	121.23	4525	94	62	91	61	86	59	33	-3			
Chico Exp Sta	Butte	14	39.70	121.78	205	105	70	102	69	96	68	37	22	2878		
China Lake	San	14	35.70	117.68	2220	112	70	108	68	104	68	33	15	2560		
Chino	San Bernardino	10	34		714	104	70	100	69	94	68	35	27			
Chino Hills	San Bernardino	10	34.1		800	104	70	100	69	94	68	35	27			
Chowchilla	Madera	13	37		200	104	72	101	70	96	68	38	22			
Chula Vista	San Diego	7	32.59	117.08	9	90	70	84	68	79	66	9	33	2072		
Citrus Heights	Sacramento	12	38.70	121.45	138	104	71	100	70	94	68	36	24			
Claremont	Los Angeles	9	34.09	117.80	1201	101	69	97	68	91	66	34	29	2049		
Clarksburg	Yolo	12	38.40	121.53	14	102	70	97	69	91	67	35	24	2971		
Clayton	Contra Costa	12	38		60	102	70	97	68	89	65	34	27			
Clearlake Highlands	Lake	2	39	122.72	1360	101	69	97	68	89	65	36	15			
Gloverdale	Sonoma	2	38.79	122.98	320	102	70	97	69	89	66	37	26	2763		
Glovis	Fresno	13	36.79	110.72	404	105	72	102	70	98	68	36	22			

City	County	Climate Zone	Latitude	Longitude	Elevation		SUMMER								Winter Median of Extremes	HDD*
							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Coachella	Riverside	15	33.70		-76	114	74	110	73	106	73	28	25			
Calinda	Fresno	13	36.20	120.35	671	103	70	98	70	93	69	34	23	2592		
Gefax	Placer	14	39.09	120.95	2418	100	66	97	65	92	63	29	22	3424		
Celton	San Bernardino	10	34.09		978	105	70	102	68	97	67	35	28			
Celusa	Celusa	14	39.20	122.02	60	103	72	100	70	94	68	36	23	2793		
Commerce	Los Angeles	8	33.90		175	98	69	92	68	86	67	23	33			
Compton	Los Angeles	8	33.90	118.22	74	97	69	90	68	83	67	24	33	1606		
Concord	Contra Costa	12	38	112.00	195	102	70	97	68	89	65	34	27	3035		
Cercoran	Kings	13	36.09	110.70	200	106	72	102	71	98	70	36	22	2666		
Cernina	Tehama	14	39.9		487	106	71	103	70	98	67	33	23			
Cerona	Riverside	10	33.90	117.57	710	104	70	100	69	92	67	35	26	1794		
Coronado	San Diego	7	32.70	117.17	20	89	69	82	67	76	65	40	36	1500		
Corte Madera	Marin	2	37.90		55	97	68	91	66	84	64	34	28			
Costa Mesa	Orange	6	33.70	117.88	100	88	68	81	66	73	65	16	31	1482		
Cotati	Sonoma	2	38.3		100	99	69	94	68	89	66	32	24			
Country Club	San Joaquin	12	37.8		600	102	69	97	68	92	66	30	68			
Covelo	Mendocino	2	39.79	123.25	1385	99	67	93	65	87	63	43	15	4179		
Covina	Los Angeles	9	34.09		575	101	70	97	69	91	68	34	29			
Crescent City	Del Norte	1	41.79	124.20	40	75	61	69	59	65	58	18	28	4445		
Crestline	San Bernardino	16	34.2		4900	90	62	86	61	84	59	26	13			
Crockett	Contra Costa	12	38	122.22	9	96	68	90	66	85	64	23	28			
Crows Landing	Stanislaus	12	37.40	121.10	140	101	70	96	68	89	66	33	23	2767		
Cucamonga	San Bernardino	10	34.09		1450	103	69	99	68	93	65	34	29			
Cudahy	Los Angeles	8	33.90		130	98	70	91	69	85	67	24	33			
Culver City	Los Angeles	8	34	118.40	106	96	70	88	69	83	67	18	35	1515		
Cupertino	Santa Clara	4	37.29	122.00	70	96	68	88	67	80	64	30	28			
Cuyama	Santa Barbara	4	34.00	116.58	2255	99	68	96	67	89	66	42	13			
Cuyamaca	San Diego	7	33		4650	92	64	85	62	84	59	29	44	4848		
Cypress	Orange	8	33.70		75	98	70	92	69	85	67	24	34			
Daggett AP	San Bernardino	14	34.90	116.78	1915	109	68	106	68	102	66	33	24	2203		
Daly City	San Mateo	3	37.50	122.50	410	84	65	78	62	73	64	16	34			
Dana Point	Orange	6	33.5		100	91	69	84	68	78	66	13	30			
Danville	Contra Costa	12	37.8		368	102	69	97	68	92	66	30	23			
Davis	Yolo	12	38.5	121.77	60	103	72	99	70	93	68	44	24	2844		
De-Sable	Butte	14	39.00	121.62	2713	97	66	94	64	88	62	35	18	4237		
Death Valley	Inyo	14	36.5	116.87	194	121	77	118	76	114	74	28	27	4147		
Deep Springs Clg	Inyo	16	37.5	117.98	5225	98	60	95	59	92	58	35	3			
Deer Creek PH	Nevada	16	39.20	120.85	4455	93	61	91	60	87	58	39	10	5863		
Del Aire	Los Angeles	6	34		100	91	69	84	67	79	66	15	37			
Delane	Kern	13	35.70		323	106	71	102	70	98	69	36	22			
Denair	Stanislaus	12	37.59	120.78	137	100	70	95	69	89	67	38	22	2974		
Desert Hot Springs	Riverside	15	34		1060	115	73	111	72	107	74	35	24			
Diamond Bar	Los Angeles	9	34		880	101	69	97	68	92	66	33	28			
Dinuba	Tulare	13	36.5		340	104	73	101	70	96	69	36	24			
Discovery Bay	Contra Costa	12	38.4		10	102	70	97	68	89	65	34	27			
Dixon	Solano	12	38.40	121.85	100	104	72	99	70	93	68	36	24	2826		
Debbins	Yuba	11	39.40	121.20	1640	104	70	101	68	96	67	31	24			
Donner Mem Stt Pk	Nevada/Placer	16	39.20	120.25	5937	85	56	82	56	77	54	40	3			
Donner Summit	Placer	16	39.40	120.33	7239	80	53	77	53	72	50	40	8	8200		
Downey	Los Angeles	8	33.90	118.00	110	98	71	90	70	84	68	21	32			

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							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Downieville RS	Sierra	16	39.59	120.80	2895	98	64	95	63	90	64	42	13			
Devle	Lassen	16	40	120.10	4390	96	63	93	62	88	59	42	0			
Dry Canyon Res	Ventura	16	34.5	118.53	1455	105	71	100	69	96	68	32	24			
Duarte	Los Angeles	9	34.09		500	100	69	96	68	90	67	33	31			
Dublin	Alameda	12	37.70	121.50	200	99	69	93	67	86	65	35	24			
Dudleys	Mariobea	12	37.70	120.10	3000	97	65	94	64	90	62	44	10	4959		
Duttons Landing	Napa	2	38.2	122.30	20	96	68	91	66	84	64	34	26			
Eagle Mtn	Riverside	14	33.70	115.45	973	113	72	110	71	105	69	24	32	1138		
Earlimart	Tulare	13	35.8		283	106	71	102	70	98	69	36	23			
East Compton	Los Angeles	8	34			74	97	69	90	68	83	67	24	33		
East Hemet	Riverside	10	33.7		1655	109	70	104	69	101	67	40	20			
East La Mirada	Los Angeles	9	33.9			115	99	70	91	69	85	68	26	34		
East Los Angeles	Los Angeles	9	34	118.25	250	99	69	92	68	86	67	24	38			
East Palo Alto	San Mateo	3	37.5			25	93	66	85	64	77	62	25	26		
East Park Res	Colusa	11	39.40	122.52	1205	101	69	97	68	92	66	38	19	3455		
East Pasadena	Los Angeles	16	34.2			864	99	69	94	68	88	67	30	32		
East Porterville	Tulare	13	36.1			393	106	71	102	70	97	69	36	25		
East San Gabriel	Los Angeles	9	34.1			450	99	70	94	69	88	68	30	30		
Edwards AFB	Kern	14	34.90	117.87	2316	107	69	104	68	99	66	35	10	3123		
El Cajon	San Diego	10	32.70	116.95	525	96	70	91	69	87	67	30	29			
El Capitan Dam	San Diego	14	32.90	116.82	600	105	71	98	70	93	68	35	29	1533		
El Centro	Imperial	15	32.79	115.57	-30	115	74	111	73	107	73	34	26	1212		
El Cerrito	Contra Costa	3	37.70			70	91	66	84	64	75	62	17	30		
El Dorado Hills	El Dorado	12	38.6			673	103	70	100	69	94	67	36	24		
El Mirage	San Bernardino	14	34.59		2910	105	69	101	68	97	66	34	9			
El Monte	Los Angeles	9	34.09			274	101	71	97	70	91	68	30	34		
El Paso de Robles	San Luis Obispo	4	35.6			724	102	65	95	65	90	65	44	16		
El Rio	Ventura	6	34.29			50	95	69	88	68	82	66	20	30		
El Segundo	Los Angeles	6	33.90			105	91	69	84	68	79	66	14	37		
El Sobrante	Contra Costa	3	37.9			55	91	66	87	65	82	64	25	30		
El Toro MCAS	Orange	8	33.70	117.73	380	96	69	89	69	82	68	26	34	1591		
El Toro Station	Orange	8	33.7			380	96	69	89	69	82	68	26	34		
Electra PH	Amador	12	38.29	120.67	715	106	70	102	69	98	68	44	23	2858		
Elk Grove	Sacramento	12	38.4			50	104	71	100	69	94	68	35	29		
Elk Valley	Del Norte	16	42	123.72	1705	96	65	90	63	84	64	39	16	5404		
Elsinore	Riverside	10	33.70	117.33	1285	105	71	101	70	98	69	39	22	2128		
Encinitas	San Diego	7	33			50	87	68	83	67	77	65	10	35		
Encino	Los Angeles	9	34.2			750	103	71	98	69	92	67	27	28		
Enterprise	Shasta	11	40.50			470	107	69	103	68	97	67	29	26		
Escondido	San Diego	10	33.09	117.08	660	97	69	90	68	84	67	29	26	2005		
Eureka	Humboldt	1	40.79	124.17	43	75	61	69	59	65	58	11	30	4679		
Exeter	Tulare	13	36.3			350	104	72	101	71	97	69	39	24		
Fair Oaks	Sacramento	12	38.70	121.27	50	104	70	100	69	94	69	36	23			
Fairfax	Marin	2	38			110	96	68	90	66	83	63	34	26		
Fairfield FS	Solano	12	38.29	122.03	38	103	69	98	68	94	66	34	24	2686		
Fairmont	Los Angeles	14	34.70	118.43	3060	100	67	96	66	92	65	22	22	3330		
Fairview	Tulare	16	35.9			3519	97	67	94	66	90	64	43	11		
Fallbrook	San Diego	10	33.59	117.25	660	94	68	89	67	85	66	29	26	2077		
Farmersville	Tulare	13	36.3			350	104	72	101	72	97	69	39	24		
Felton	Santa Cruz	3	37			100	94	68	88	66	84	64	28	27		

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						0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Ferndale	Humboldt	1	40.5	124.30	1445	76	57	66	56	62	54	12	28		
Fillmore	Ventura	9	34.40		435	100	70	94	69	87	67	30	28		
Five Points	Fresno	13	36.40	120.15	285	103	71	99	70	93	68	36	24		
Fleming-Fish & Lassen	Lassen	16	40.40	120.32	4000	96	62	93	61	88	59	40	3		
Florence-Graham	Los Angeles	8	34		175	98	69	90	68	84	67	19	35		
Florin	Sacramento	12	38.5		100	104	71	100	69	94	68	35	29		
Folsom-Dam	Sacramento	12	38.70	121.17	350	104	70	101	69	95	67	36	25		
Fontana	San Bernardino	10	34.00	117.43	1000	105	70	101	69	97	67	33	30	1530	
Foothill-Farms	Sacramento	12	38.6		90	104	71	100	70	94	68	36	24		
Forest-Glen	Trinity	16	40.40	123.33	2340	96	65	92	64	88	62	42	12		
Fort Baker	Marin	3	37.79	122.47	15	87	66	84	65	73	65	12	33	3080	
Fort Bidwell	Modoc	16	41.00	120.13	4498	93	60	90	59	85	57	38	2	6381	
Fort Bragg	Mendocino	4	39.5	123.82	80	75	60	67	59	62	58	15	29	4424	
Fort Jones-RS	Siskiyou	16	41.59	122.85	2725	98	64	93	63	88	64	44	5	5590	
Fort MacArthur	San Diego	7	33.70	118.30	200	92	69	84	68	78	66	13	35	1810	
Fort Ord	Monterey	3	36.70	121.77	134	86	65	77	63	70	60	18	24	3818	
Fort Ross	Sonoma	1	38.5	123.25	116	79	63	74	62	65	59	19	30	4127	
Fortuna	Humboldt	1	40.6		100	75	61	69	59	65	58	11	30		
Foster City	San Mateo	3	37.5	122.73	20	92	67	84	65	76	63	22	29		
Fountain Valley	Orange	6	33.70		60	97	70	90	68	84	67	18	33		
Freedom	Santa Cruz	3	37		1495	89	67	85	64	79	62	22	27		
Fremont	Alameda	3	37.5	122.00	56	94	67	88	65	81	63	24	25		
Fresno-AP	Fresno	13	36.79	119.72	328	104	73	101	71	97	68	34	24	2650	
Friant-Gov Camp	Fresno	13	37	119.72	410	106	72	103	70	100	68	40	23	2768	
Fullerton	Orange	8	33.90		340	100	70	94	69	87	68	26	30		
Galt	Sacramento	12	38.2		40	104	70	97	68	91	67	38	23		
Garden Acres	San Joaquin	12	38		20	103	71	98	69	93	67	35	24		
Garden Grove	Orange	8	33.59		85	98	70	91	68	84	67	23	31		
Gardena	Los Angeles	8	33.90		40	92	69	85	68	80	66	18	32		
George-AFB	San Bernardino	14	34.59	117.38	2875	105	67	102	65	98	62	34	19	2887	
Georgetown-RS	El Dorado	12	38.90	120.78	3001	98	64	95	63	90	64	34	18		
Giant Forest	Tulare	16	36.59	118.77	6412	84	56	81	55	77	53	26	5		
Gillespie Field	Solano	12	32.79		385	98	71	91	70	85	68	30	24		
Gilroy	Santa Clara	4	37	121.57	194	104	70	93	68	86	65	25	23		
Glen Aven	Riverside	10	34		827	105	70	101	69	95	67	35	28		
Glendale	Los Angeles	9	34.20		563	101	70	96	68	90	67	28	30		
Glendora	Los Angeles	9	34.09		822	102	69	98	68	92	67	35	30		
Glennville	Kern	16	35.70	118.73	3140	97	67	94	66	90	64	43	11	4423	
Gold Rock-Rch	Imperial	15	32.90		485	113	73	110	72	106	70	28	31		
Golden Hills	Kern	16	35.1		4000	97	66	93	65	89	64	33	13		
Granada Hills	Los Angeles	6	34.4	118.53	1032	100	70	95	68	89	66	37	28		
Grand Terrace	San Bernardino	10	34.1		1000	105	70	102	68	97	67	35	28		
Grant Grove	Tulare	16	36.70	118.97	6600	82	56	78	55	74	52	26	6	7044	
Grass Valley	Nevada	14	39.20	121.07	2400	99	67	96	65	94	63	29	19		
Graton	Sonoma	2	38.40	122.87	200	95	68	91	67	82	64	34	22	3409	
Greenacres	Kern	13	35.3		400	106	71	102	70	98	68	34	26		
Greenfield	Monterey	4	36.2		287	92	67	88	65	84	64	32	22		
Grossmont	San Diego	7	32.70		530	96	69	89	68	84	66	23	31		
Grover City	San Luis Obispo	5	35.09		100	93	69	86	64	80	62	18	30		
Guadalupe	Santa Barbara	5	35		85	92	66	86	64	79	62	18	28		

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							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Hacienda Hts	Los Angeles	9	34		300	100	69	96	68	90	67	28	31			
Haiwee	Inyo	16	36.09	117.95	3825	102	65	99	64	95	62	27	15	3700		
Half Moon Bay	San Mateo	3	37.5	122.43	60	83	64	76	62	69	59	15	32	3843		
Hamilton AFB	Marin	2	38.09	122.50	3	95	69	88	67	84	65	28	27	3311		
Hanford	Kings	13	36.29	119.67	242	102	71	99	70	94	68	37	22	2736		
Happy Camp RS	Siskiyou	16	41.79	123.37	1150	103	67	97	66	92	65	44	18	4263		
Hat Creek PH 1	Shasta	16	40.90	121.55	3015	99	65	96	64	91	62	48	2	5689		
Hawaiian Gardens	Los Angeles	8	33.79		75	97	70	94	69	84	67	23	32			
Hawthorne	Los Angeles	8	33.90		70	92	69	85	68	80	66	16	37			
Havfield Pumps	Riverside	14	33.70	115.63	1370	112	71	108	70	104	68	34	24	1529		
Hayward	Alameda	3	37.70	122.12	530	92	66	86	65	84	62	24	26	2909		
Healdsburg	Sonoma	2	38.59	122.87	102	102	69	95	68	90	66	37	26	2572		
Hemet	Riverside	10	33.70		1655	109	70	104	69	101	67	40	20			
Henshaw Dam	San Diego	10	33.20		2700	99	68	94	67	90	66	38	15	3708		
Hercules	Contra Costa	3	38		15	91	66	87	65	82	64	25	30			
Hermosa Beach	Los Angeles	6	33.90		16	92	69	84	68	78	66	12	38			
Hesperia	San Bernardino	14	34.4		3191	105	67	101	65	97	63	38	14			
Hetch Hatchy	Tuolumne	16	38	119.78	3870	93	62	89	61	85	59	32	14	4816		
Highland	San Bernardino	10	34.09		1315	106	70	102	69	97	68	36	26			
Hillcrest Center	Kern	16	35.40		500	106	71	102	70	98	68	34	26			
Hillsborough	San Mateo	3	37.59	122.30	352	90	66	82	65	74	64	23	30			
Hilt	Siskiyou	16	42	122.63	2900	97	64	93	62	89	60	39	5			
Hollister	San Benito	4	36.90	121.42	280	96	68	89	67	84	65	30	24	2725		
Hollywood	Los Angeles	9	34	118.38	384	96	70	89	69	83	67	20	36			
Home Gardens	Riverside	10	33.9		678	104	70	100	69	92	67	35	26			
Hoopa	Humboldt	2	41	123.67	360	100	67	92	66	87	64	25	23			
Huntington Beach	Orange	6	33.70	117.80	40	91	69	83	67	76	66	14	34			
Huntington Lake	Fresno	16	37.20	119.22	7020	80	55	77	54	73	54	25	3	7632		
Huntington Park	Los Angeles	8	34	118.00	175	98	70	90	69	84	67	20	38			
Idlewild	Del Norte	1	41.90	124.00	1250	103	68	96	66	92	65	40	18			
Idria	San Benito	4	36.40	120.67	2650	97	66	92	65	87	62	27	24	3128		
Idyllwild	Riverside	16	33.70	116.72	5397	93	62	89	61	84	60	35	9			
Imperial AP	Imperial	15	32.79	115.57	-59	114	74	110	73	106	72	34	26	1060		
Imperial Beach	San Diego	7	32.5	117.12	23	87	69	82	68	78	67	10	35	1839		
Imperial CO	Imperial	15	32.90		-64	112	73	108	72	104	71	31	29	976		
Independence	Inyo	16	36.79		3950	104	61	101	60	97	60	34	12			
Indio	Riverside	15	33.70	116.25	11	115	75	112	75	107	74	30	24	1059		
Inglewood	Los Angeles	8	33.90	118.00	105	92	68	85	67	80	65	15	37			
Inyokern NAS	Kern	14	35.70	117.82	2440	110	71	106	68	102	66	37	15	2772		
Ione	Amador	12	38.3		298	101	70	97	68	91	67	38	23			
Iron Mtn	Shasta	11	34.09	115.13	922	116	75	112	74	108	73	26	29	1251		
Irvine	Orange	8	33.70	118.00	50	96	69	88	68	82	67	27	33			
Isla Vista	Santa Barbara	6	34.5		40	90	69	83	67	77	65	20	33			
Jess Valley	Medoc	16	41.29		5300	92	59	89	58	84	56	35	7	7045		
John Wayne AP	Orange	6	33.59		115	98	70	91	68	84	67	26	33	1496		
Julian Wynola	San Diego	14	33.09	116.80	3650	96	66	91	64	87	62	39	20	4049		
Kentfield	Marin	2	38	122.55	120	97	66	91	65	84	63	35	27	3009		
Kerman	Fresno	13	36.6		216	105	73	101	71	97	68	34	24			
Kern River PH 1	Kings	13	35.5	118.78	970	106	72	103	71	99	69	26	30	1878		
Kern River PH 3	Kern	16	35.70	118.57	2703	103	69	100	68	96	66	34	19	2891		

City	County	Climate Zone	Latitude	Longitude	Elevation		SUMMER								Winter Median of Extremes	HDD*
							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Kettleman-Stn	Kings	13	36.09	120.08	508	104	71	100	70	93	68	31	26	2180		
King City	Monterey	4	36.20	121.13	320	94	67	90	65	85	64	36	20	2639		
Kingsburg	Fresno	13	36.4		297	104	73	101	71	97	69	36	24			
Klamath	Del Norte	4	41.5	124.08	25	79	62	71	60	66	58	18	26	4509		
Knights Ferry	Stanislaus	12	37.79	120.57	315	103	70	99	68	94	67	37	19			
La Canada-Flintridge	Los Angeles	9	34.20	118.00	1365	99	69	95	68	88	66	30	32			
La Crescenta-	Los Angeles	9	34.20	118.00	1565	98	69	94	68	87	66	33	31			
La Habra	Orange	9	33.90	118.00	305	100	69	94	68	87	67	27	30			
La Habra Heights	Los Angeles	9	34		400	100	69	94	68	87	67	27	30			
La Mesa	San Diego	7	32.79	117.02	530	94	70	88	69	84	67	23	34	1567		
La Mirada	Los Angeles	9	33.90	118.00	115	99	70	91	69	85	68	26	31			
La Palma	Orange	8	33.90	118.00	75	98	69	92	68	85	67	25	31			
La Puente	Los Angeles	9	34	118.00	320	101	71	97	70	91	69	28	31			
La Quinta	Riverside	15	33.8		400	116	74	112	73	108	72	34	26			
La Riviera	Sacramento	12	38.6		190	104	71	100	70	94	68	32	30			
La Verne	Los Angeles	9	34.09	118.00	1235	101	69	97	68	91	67	34	29			
Ladera Heights	Los Angeles	9	34.1		100	91	67	84	67	79	66	14	37			
Lafayette	Contra Costa	12	37.90	122.13	535	100	69	94	67	87	66	32	24			
Laguna Beach	Orange	6	33.5	117.78	35	91	69	83	68	76	66	18	30	2222		
Laguna Niguel	Orange	6	33.6		500	95	67	87	66	84	63	22	33			
Lake Arrowhead	San Bernardino	16	34.2	117.18	5205	90	62	86	64	81	59	26	13	5310		
Lake Elsinore	Riverside	10	33.7		1233	105	70	101	69	97	68	39	22			
Lake Los Angeles	Los Angeles	14	34.7		2300	106	68	102	67	98	66	35	12			
Lake Spaulding	Nevada	16	39.29	120.63	5156	89	58	86	57	83	55	34	3	6447		
Lakeland Village	Riverside	10	33.6		1233	105	70	101	69	97	68	39	12			
Lakeport	Lake	2	39	122.92	1347	97	67	93	66	88	63	41	29	3728		
Lakeshore	Fresno	16	40.00		1075	104	69	100	68	95	66	28	29			
Lakeside	San Diego	10	32.79	117.00	600	95	69	90	68	86	66	20	26			
Lakewood	Los Angeles	8	33.90	118.00	45	98	70	90	68	84	66	22	33			
Lamont	Kern	13	35.29	120.00	500	106	72	102	71	98	69	34	26			
Lancaster	Los Angeles	14	34.70	118.20	2340	106	68	102	67	98	66	35	12			
Larksfield-Wikiup	Sonoma	2	38.5		170	99	69	96	68	92	66	35	24			
Larkspur	Marin	2	37.90	122.50	20	97	68	94	66	84	64	34	28			
Las Plumas	Butte	14	39.70		506	104	71	101	70	96	68	32	24			
Lathrop	San Joaquin	12	37.8		22	103	71	98	69	93	67	35	24			
Lava-Beds	Siskiyou	16	41.70	121.52	4770	93	59	89	58	84	56	44	-1			
Lawndale	Los Angeles	8	33.90	118.00	66	92	69	85	68	80	66	16	37			
Le Grand	Merced	12	37.20	120.25	255	101	70	96	68	91	66	38	23	2696		
Lemon Grove	San Diego	7	32.70	117.20	437	96	71	88	69	84	67	19	34			
Lemon Grove	Tulare	13	36.40	119.03	513	105	72	102	70	98	68	38	25	2513		
Lemoore-NAS	Kings	13	36.29	119.95	228	104	72	101	71	97	69	37	19	2960		
Lennox	Los Angeles	8	33.90	117.75	71	92	69	85	68	80	66	16	37			
Lincoln-Village	San Joaquin	12	38		42	101	70	96	68	91	67	37	24			
Linda	Yuba	14	39		60	105	72	102	70	97	68	30	27			
Lindsay	Tulare	13	36.20	119.07	395	105	72	101	71	97	69	40	24	2634		
Little Pinecone	Fresno	13	36.70		677	100	68	94	67	86	66	33	23			
Live Oak	Sutter	11	39.2		75	105	70	102	69	97	69	36	24			
Livermore	Alameda	12	37.70	121.95	490	100	69	95	68	88	67	35	22	3012		
Livingston	Merced	12	37.3		465	103	72	100	70	95	68	39	24			
Hlano Shawnee	Los Angeles	14	34.5	117.75	3820	104	68	99	67	95	65	31	24			

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							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Lodgingpole	Lassen	16	36.59	118.72	6735	84	57	80	56	78	54	26	4			
Lodi	San Joaquin	12	38.09	121.28	40	101	70	97	68	91	67	38	23	2859		
Loma Linda	San Bernardino	10	34	117.50	1150	106	70	103	69	99	67	36	27			
Lomita	Los Angeles	6	33.79	119.00	56	95	69	87	68	84	66	18	33			
Lompoc	Santa Barbara	5	34.90	120.45	95	84	63	77	62	72	60	18	26	2888		
Long Beach AP	Los Angeles	6	33.79	118.23	25	99	71	90	69	84	66	24	33	1606		
Long Beach	Los Angeles	6	33.70	118.15	34	97	70	88	68	82	65	18	35			
Loomis	Placer	11	38.8		408	107	71	103	70	98	69	39	24			
Los Alamitos NAS	Orange	8	33.79	118.05	30	98	71	89	69	83	68	23	32	1740		
Los Altos	Santa Clara	4	37.29	122.00	163	96	68	88	65	80	62	26	28			
Los Altos Hills	Santa Clara	4	37.3		183	93	67	85	64	77	63	25	28			
Los Angeles AP	Los Angeles	6	33.90	118.40	97	94	67	84	67	79	66	14	37	1819		
Los Angeles CO	Los Angeles	9	34	118.23	270	99	69	92	68	86	67	24	38	1245		
Los Banos	Merced	12	37	120.87	120	100	70	96	68	88	67	42	22	2616		
Los Banos Res	Merced	12	37	120.87	407	101	70	97	68	89	67	42	23			
Los Gatos	Santa Clara	4	37.20	121.97	365	98	69	90	67	82	66	32	26	2741		
Los Serranos	San Bernardino	10	34.1		714	104	70	100	69	94	68	35	27			
Lucas Vly	Sonoma	2	38.3		20	79	63	74	62	65	59	12	30			
Lucerne Valley	San Bernardino	14	34.5	116.95	2957	105	67	101	66	98	64	38	12			
Lynwood	Los Angeles	8	33.90	118.00	88	98	70	90	69	83	67	24	32			
Madera	Madera	13	37	120.07	268	105	72	101	70	96	68	40	24	2673		
Madera Acres	Madera	13	36.9		275	105	72	101	70	96	68	40	24			
Manhattan Beach	Los Angeles	6	33.90	118.00	120	94	69	84	68	79	66	12	38			
Manteca	San Joaquin	12	37.79	121.20	34	102	70	97	68	91	67	37	24			
Manzanita Lake	Shasta	16	40.5	121.57	5850	87	58	84	57	79	55	34	3	7617		
March AFB	Riverside	10	33.90	117.25	1511	103	70	99	68	94	65	34	23	2089		
Maricopa	Kern	13	35.09	119.38	675	106	71	102	70	98	68	29	25	2302		
Marina	Monterey	3	36.70		20	86	66	77	63	70	64	18	32			
Marina del Rey	Los Angeles	9	34.1		40	94	69	84	68	79	66	12	38			
Markley Cove	Napa	2	38.5	122.12	480	104	70	99	69	93	67	39	23			
Martinez FS	Contra Costa	12	38	122.13	40	99	67	94	66	88	65	36	28			
Marysville	Yuba	11	39.20	121.58	60	105	72	102	70	97	68	36	27	2552		
Mather AFB	Sacramento	12	38.59	121.30	96	104	71	100	70	94	68	35	28			
Maywood	Los Angeles	8	34	118.00	170	97	70	94	69	85	67	24	34			
McClellan AFB	Sacramento	12	38.70	121.40	86	105	71	102	70	96	68	35	23	2566		
McCloud	Siskiyou	16	41.29	122.13	3300	96	63	93	62	87	60	42	5	5990		
McFarland	Kern	13	35.6		350	106	71	102	70	98	69	36	22			
McKinleyville	Humboldt	1	40.9		33	75	61	69	59	65	58	11	28			
Mecca FS	Riverside	15	33.59	116.07	180	115	75	111	75	107	74	30	24	1185		
Mendota	Fresno	13	36.7		169	105	73	101	71	97	68	34	24			
Mentor Park	San Mateo	3	37.40	122.33	65	94	67	86	65	78	63	25	27			
Mentone	San Bernardino	10	34.1		1700	106	70	102	69	98	67	34	27			
Merced AP	Merced	12	37.29	120.57	153	103	71	100	69	95	67	36	24	2653		
Mill Creek	Tehama	16	35.09	117.02	2940	102	67	97	66	94	65	28	28			
Mill Valley	Marin	3	37.90	122.58	80	97	68	94	66	84	64	28	28	3400		
Millbrae	San Mateo	3	37.59	122.35	10	90	66	82	63	74	64	24	30			
Milpitas	Santa Clara	4	37.40	121.90	15	94	68	87	65	79	63	27	27			
Mineral	Tehama	16	40.40	121.60	4911	90	60	87	59	82	57	38	2	7257		
Mira Loma	Riverside	10	34		700	105	70	101	69	95	66	34	25			

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							0.1% Dry Bulb	0.1 % Wet Bulb	0.5% Dry Bulb	0.5 % Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Dail y Ran ge			
Miramar AFS	San Diego	7	32.90	117.13	477	97	69	94	68	86	67	22	32	1532		
Miramonte	Fresno	13	34.4		750	102	71	97	69	94	68	38	25			
Mission Viejo	Orange	8	33.59	118.00	350	95	67	87	66	84	63	22	33			
Mitchell Caverns	San Bernardino	14	34.90		4350	102	64	98	63	94	64	29	24			
Modesto	Stanislaus	12	37.59	121.00	94	102	73	99	70	95	68	36	25	2671		
Moffett Field-NAS	Santa Clara	4	37.40	122.05	39	89	68	84	66	78	64	23	30	2511		
Mojave	Kern	14	35.09	118.18	2735	106	68	102	67	98	66	35	16	3012		
Mono Lake	Mono	16	38	119.15	6450	94	58	88	57	84	55	32	4	6518		
Monrovia	Los Angeles	9	34.20	118.30	562	100	69	96	68	90	67	30	33			
Montague	Siskiyou	16	41.79	122.47	2648	99	66	95	65	90	63	39	3	5474		
Montclair	San Bernardino	10	34	117.00	4220	104	69	100	68	94	66	35	28			
Montebello	Los Angeles	9	34	118.10	205	98	69	93	68	86	67	24	33			
Monterey AP	Monterey	3	36.59	121.87	245	86	65	77	62	70	64	20	30	3556		
Monterey CO	Monterey	3	36.59	121.87	345	87	65	78	62	71	64	20	32	3169		
Monterey Park	Los Angeles	9	34	118.00	380	99	69	94	68	87	67	23	30			
Monticello-Dam	Solano	2	38.5	122.12	505	105	71	100	70	94	68	39	26			
Moraga	Contra Costa	12	37.79	122.17	600	99	68	93	66	86	64	27	24			
Moreno Valley	Riverside	10	33.9		1600	103	70	99	68	94	65	34	27			
Morgan Hill	Santa Clara	4	37.09	120.00	350	100	69	92	68	85	66	25	26			
Morro Bay FD	San Luis Obispo	5	35.40	120.85	415	88	65	82	64	76	62	14	34			
Mount Baldy-Notch	San Bernardino	16	34.29	117.62	7735	80	58	76	57	71	54	32	4			
Mount Diablo	Contra Costa	12	37.90	121.92	2100	101	68	96	66	87	65	28	27	4600		
Mount Hamilton	Santa Clara	4	37.29	121.65	4206	95	59	88	58	84	56	18	18	4724		
Mount Hebron RS	Siskiyou	16	41.79	122.02	4250	92	60	88	59	82	57	42	10			
Mount San Jacinto	Riverside	16	33.79	116.63	8417	82	56	77	55	73	53	35	1			
Mount Shasta	Siskiyou	16	41.29	122.32	3535	93	62	89	61	84	59	34	8	5890		
Mount Wilson	Los Angeles	16	34.20	118.07	5709	90	63	85	64	79	58	21	15	4296		
Mountain Pass	San Bernardino	14	35.5	115.53	4730	100	65	96	64	92	63	29	44			
Mountain View	Santa Clara	4	37.5	121.90	95	93	67	85	64	77	62	25	28			
Muscoy	San Bernardino	10	34.2		1400	105	71	101	69	96	66	37	26			
Nacimiento Dam	San Luis Obispo	4	35.70	120.88	770	100	68	94	66	88	64	35	22			
Napa State Hospital	Napa	2	37.29	122.27	60	94	67	91	67	86	66	29	26	2749		
National City	San Diego	7	32.70	117.00	34	87	70	82	68	78	66	10	36			
Needles AP	San Bernardino	15	34.79	114.62	913	117	73	114	72	110	74	26	27	1391		
Nevada City	Nevada	11	39.29	121.02	2600	97	66	94	64	88	63	41	44	4900		
Newark	Alameda	3	37.5	122.03	40	94	68	89	67	82	65	24	29			
Newhall-Soledad	Los Angeles	9	34.40	118.55	1243	104	70	100	68	95	67	42	27			
Newman	Stanislaus	12	37.29	121.05	90	104	71	99	69	93	67	38	22			
Newport Beach	Orange	6	33.59	117.88	10	87	68	80	66	72	65	12	34	1952		
Nipomo	San Luis Obispo	5	35		330	90	66	83	64	78	61	23	25			
Norce	Riverside	10	33.90	117.00	700	103	70	99	69	94	67	34	27			
North Auburn	Placer	11	38.9		1300	103	69	100	67	95	66	33	25			
North Fork RS	Madera	16	37.20	119.50	2630	98	66	95	65	92	62	36	45			
North Highlands	Sacramento	12	38.59	121.42	45	104	71	100	69	94	67	35	23	2566		
North Hollywood	Los Angeles	9	34.20	118.38	619	102	70	97	69	94	67	34	28			
Northridge	Los Angeles	9	34.2		875	101	70	96	69	90	67	36	30			
Norwalk	Los Angeles	8	33.9		97	99	69	90	68	84	67	26	31			
Novato	Marin	2	38.09	122.52	370	94	64	87	63	80	64	30	25			
Oakdale	Stanislaus	12	37.79	120.87	215	102	71	99	69	93	67	37	22			
Oakland AP	Alameda	3	37.70	122.20	6	94	66	84	64	77	62	20	32	2909		

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							0.1% Dry Bulb	0.1 % Wet Bulb	0.5% Dry Bulb	0.5 % Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Dail y Ran ge			
Oakland Museum	Alameda	3	37.79	122.17	30	96	68	89	66	82	63	20	31			
Oakley	Contra Costa	12	38		20	102	70	97	68	91	66	34	22			
Oceano	San Luis Obispo	5	35.4		20	93	69	86	64	80	62	18	30			
Oceanside	San Diego	7	33.20	117.40	10	84	69	80	67	74	65	10	33			
Oildale	Kern	13	35.5	119.00	450	106	71	102	70	98	68	34	26			
Ojai	Ventura	9	34.5	119.25	750	102	71	97	69	91	68	38	25	2145		
Olivehurst	Yuba	11	39		64	105	72	102	70	97	68	36	27			
Ontario-AP	San Bernardino	10	34	117.00	934	105	70	101	69	95	66	34	26	1710		
Opal Cliffs	Santa Cruz	3	37		125	94	68	88	66	81	64	28	27			
Orange	Orange	8	33.59	118.00	194	99	70	92	68	85	67	27	33			
Orange Cove	Fresno	13	36.59	119.30	431	104	71	100	69	97	68	38	25	2684		
Orangevale	Sacramento	12	38.70	121.20	140	105	72	102	70	96	68	36	24			
Oreck Prairie Creek	Humboldt	4	41.40	124.02	161	80	61	75	60	70	59	23	25	4816		
Orinda	Contra Costa	12	37.90	122.17	550	99	68	93	66	86	64	32	24			
Orland	Glenn	11	39.70	122.20	254	105	71	102	70	97	68	36	22	2824		
Orleans	Humboldt	2	41.20	123.53	403	104	70	97	68	91	66	42	24	3628		
Orosi	Tulare	13	36.5		400	104	73	101	70	96	69	36	24			
Oroville East	Butte	11	39.5		171	106	71	104	70	98	69	37	25			
Oroville RS	Butte	11	39.5	121.55	300	106	71	104	70	98	69	37	25			
Otay Castle Pk	San Diego	7	32.59	117.00	500	87	68	81	66	74	63	10	33			
Oxnard-AFB	Ventura	6	34.20	119.18	49	94	69	86	68	79	67	24	30	2068		
Pacific Grove	Monterey	3	36.70	122.00	114	87	66	78	63	74	64	19	34			
Pacifica	San Mateo	3	37.59	122.00	13	87	65	79	62	74	60	16	34			
Pacoima	Los Angeles	16	34.26	118.43	895	104	71	99	70	94	68	35	29			
Palermo	Butte	11	39.4		154	106	71	104	70	98	69	37	25			
Palm Desert	Riverside	15	33.70	116.50	200	116	74	112	73	108	72	34	26			
Palm-Desert Country	Riverside	15	33.7		243	116	74	112	73	108	72	34	26			
Palm-Springs	Riverside	15	33.79	116.53	411	117	74	113	73	109	72	35	26	4109		
Palmdale-AP	Los Angeles	14	34.59	118.10	2517	107	67	103	67	98	64	33	12	2929		
Palmdale-CO	Los Angeles	14	34.59	118.10	2596	106	67	102	67	97	64	35	13	2908		
Palo-Alto	Santa Clara	4	37.5	122.13	25	93	66	85	64	77	62	25	26	2891		
Palomar-Oceanside	San Diego	14	33.40	116.87	5545	90	62	85	61	80	59	22	16	4141		
Palos Verdes	Los Angeles	6	33.79	119.00	216	92	69	84	68	78	66	14	38			
Panorama City	Los Angeles	9	34.22	118.45	804	103	71	98	69	92	67	32	28			
Paradise	Butte	11	39.70	121.60	1750	102	69	99	67	94	66	34	25			
Paramount	Los Angeles	8	33.90	117.00	70	98	70	90	69	84	67	22	32			
Parker Res	San Bernardino	15	34.29	114.17	738	115	74	112	73	108	72	26	32	1223		
Parkway-South Sacramento	Sacramento	12	38.5		17	104	71	100	70	94	68	32	30			
Parlier	Fresno	13	36.6		320	104	73	101	71	97	68	38	24			
Pasadena	Los Angeles	9	34.20	118.15	864	99	69	94	68	88	67	30	32	1551		
Paso Robles-AP	San Luis Obispo	4	35.70	120.68	815	104	66	97	66	92	65	40	19	2973		
Paso Robles-CO	San Luis Obispo	4	35.59	120.68	700	102	65	95	65	90	65	44	16	2885		
Patterson	Stanislaus	12	37.4		97	101	72	96	70	90	67	36	24			
Pedley	Riverside	10	34		718	105	70	101	69	95	66	34	26			
Pendleton-MCB	San Diego	7	33.29	117.30	63	92	68	87	67	84	66	22	34	1532		
Pendleton-MCB	San Diego	7	33.20	117.4	24	84	69	80	67	75	65	10	39	1782		
Perris	Riverside	10	33.79	117.22	1470	105	70	101	69	97	68	39	22			
Petaluma-FS-2	Sonoma	2	38.20	122.63	16	98	69	92	67	85	66	34	24	2959		
Pico Rivera	Los Angeles	9	34	118.00	180	98	70	91	69	85	67	24	34			

City	County	Climate Zone	Latitude	Longitude	Elevation		SUMMER								Winter Median of Extremes	HDD*
							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Piedmont	Alameda	3	37.79	122.00	325	96	68	89	66	82	63	23	31			
Pinnacles NM	San Bernardino	14	36.5	121.18	1307	98	68	94	67	89	64	45	20	2956		
Pineola	Contra Costa	3	38	122.30	10	91	66	87	65	82	64	25	30			
Pismo Beach	San Luis Obispo	5	35.09	120.62	80	92	66	85	64	80	62	16	30	2756		
Pittsburg	Contra Costa	12	38	121.80	50	102	70	97	68	90	67	34	26			
Placentia	Orange	8	33.90	118.00	323	101	69	93	68	87	67	28	30			
Placerville	El Dorado	12	38.70	120.80	1890	101	67	98	66	93	65	42	20	4086		
Placerville IFG	El Dorado	12	38.70	120.80	2755	100	66	97	65	92	64	42	23			
Platina	Shasta	11	40.40	122.88	2260	96	65	92	64	87	61	36	13			
Pleasant Hill	Contra Costa	12	37.90	122.00	102	96	68	93	67	88	65	34	25			
Pleasanton	Alameda	12	37.59	121.78	350	97	68	94	67	89	65	35	24			
Point Arena	Mendocino	4	38.90	123.73	100	76	62	72	60	67	58	19	29	4747		
Point Arguello	Santa Barbara	5	34.59	120.67	76	75	64	71	63	65	59	17	29	3826		
Point Mugu	Ventura	6	34.09	119.12	14	88	68	81	67	75	66	15	33	2328		
Point Piedras	San Luis Obispo	5	35.70	121.28	59	73	60	67	59	61	57	10	36	3841		
Pomona Cal Poly	Los Angeles	9	34.09	117.82	740	102	70	98	69	93	67	36	27	1971		
Port Chicago ND	Contra Costa	12	38	122.02	50	98	69	94	68	88	66	34	28			
Port Hueneme	Ventura	6	34.20	119.00	13	88	68	81	67	75	66	15	33	2334		
Porterville	Tulare	13	36.09	119.02	393	106	71	102	70	97	69	36	25	2456		
Portola	Plumas	16	39.79	120.47	4850	92	63	89	61	84	59	48	-9	7111		
Posey 3 E	Tulare	13	35.79	119.00	4960	89	62	86	61	82	59	26	9			
Potter Valley PH	Mendocino	2	39.40	123.13	1015	101	68	96	67	89	65	40	20	3276		
Poway Valley	San Diego	10	33	117.00	500	100	70	94	69	89	68	26	29			
Priest Valley	Monterey	4	36.20	120.70	2300	97	66	93	65	88	63	34	13	4144		
Prunedale	Monterey	3	36.6		260	86	66	83	65	79	62	20	26			
Quartz Hill	Los Angeles	14	34.6		2428	106	68	102	67	98	66	35	12			
Quincy	Plumas	16	39.00	120.93	3409	101	64	98	63	93	62	45	4	5763		
Ramona Spaulding	San Diego	10	33.09	116.82	1480	103	70	97	69	92	68	40	22			
Rancho Bernardo	San Diego	10	33.02	117.06	500	96	69	91	68	85	67	26	29			
Rancho Cordova	Sacramento	12	38.59	121.30	190	104	72	100	69	94	68	35	26			
Rancho Mirage	Riverside	15	33.8		248	117	74	113	73	109	72	33	26			
Rancho Palos	Los Angeles	6	33.70	118.17	216	92	69	84	68	78	66	14	38			
Rancho San Diego	San Diego	10	32.8		300	94	69	86	68	82	66	30	34			
Rancho Santa	Orange	8	33.6		416	95	67	87	66	84	63	22	33			
Randsburg	Kern	14	35.29	117.65	3570	105	67	102	66	97	65	30	19	2922		
Red Bluff AP	Tehama	14	40.20	122.25	342	107	70	104	69	98	66	34	24	2688		
Redding FS 4	Shasta	14	40.59	122.40	470	107	69	103	68	97	67	30	26	2544		
Redlands	San Bernardino	10	34.09	117.18	1318	106	70	102	69	98	67	34	27	1993		
Redondo Beach	Los Angeles	6	33.70	118.32	45	92	69	84	68	78	66	12	37			
Redwood City	San Mateo	3	37.5	122.23	31	90	67	86	66	81	64	28	28	2599		
Reedley	Fresno	13	36.59	119.70	344	104	71	101	70	96	68	40	24			
Reseda	Los Angeles	9	34.2		736	103	71	98	69	92	67	32	28			
Rialto	San Bernardino	10	34.09	117.00	1254	105	70	101	69	96	66	35	28			
Richardson Grove	Humboldt	2	40	123.78	500	96	67	92	66	87	64	28	25			
Richmond	Contra Costa	3	37.90	121.60	55	88	65	84	64	77	62	17	31	2684		
Ridgecrest	Kern	14	35.59	117.80	2340	110	70	106	68	102	66	35	15			
Rio Del Mar	Santa Cruz	3	37		50	94	67	88	66	83	63	30	27			
Rio Linda	Sacramento	12	38.6		86	104	72	100	70	94	68	32	28			
Ripon	San Joaquin	12	37.7		64	102	70	97	68	91	67	37	23			
Riverbank	Stanislaus	12	37.7		133	102	73	99	70	95	68	36	25			

City	County	Climate Zone	Latitude	Longitude	Elevation		SUMMER								Wint er Medi an of Extre mes	HDD*
							0.1% Dry Bulb	0.1 % Wet Bulb	0.5% Dry Bulb	0.5 % Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Dail y Ran ge			
Riverside Exp Sta	Riverside	10	34	117.38	986	106	71	102	69	97	67	36	29			
Riverside FS 3	Riverside	10	34	117.38	840	104	70	100	69	95	65	37	27	1818		
Rocklin	Placer	14	38.79	121.23	239	108	72	104	70	99	69	39	29	3143		
Redee	Contra Costa	3	38.1		15	93	67	90	66	84	64	23	28			
Rohnert Park	Sonoma	2	38.40	122.55	406	99	69	96	68	92	66	33	24			
Rolling Hills	Los Angeles	6	33.59	119.00	216	92	69	84	68	78	66	15	38			
Rosamond	Kern	14	34.8		2326	106	68	102	67	98	66	35	16			
Roseland	Sonoma	2	38.4		167	99	69	96	68	92	66	35	24			
Rosemead	Los Angeles	9	34	118.00	275	98	70	90	69	84	67	27	30			
Rosemont	Sacramento	12	38.3		190	104	71	100	70	94	68	32	30			
Roseville	Placer	14	38.70	121.22	160	105	71	102	70	96	68	36	24			
Rossmoor	Orange	8	33.79		20	92	67	85	64	79	62	19	32			
Rowland Hts	Los Angeles	9	33.90	118.00	540	99	70	93	69	86	68	27	29			
Rubidoux	Riverside	10	34	117.00	792	106	71	102	70	97	68	36	27			
Sacramento AP	Sacramento	12	38.5	121.50	17	104	72	100	70	94	68	35	26	2843		
Sacramento CO	Sacramento	12	38.50	121.50	84	104	71	100	70	94	68	32	30			
Saint Helena	Napa	2	38.5	122.47	225	102	70	98	69	93	67	40	22	2878		
Saint Mary's College	Contra Costa	12	37.79	122.12	623	98	69	93	68	86	66	28	24	3543		
Salinas 3-E	Monterey	3	36.70	121.60	85	86	66	83	65	79	62	20	26			
Salinas AP	Monterey	3	36.70	121.60	69	85	67	82	65	78	62	20	28	2959		
Salt Springs PH	Amador/Calavaras	16	38.5	120.22	3700	95	62	92	64	87	59	27	19	3857		
Salver RS	Trinity	16	40.90	123.57	623	102	69	95	67	87	64	33	22			
San Anselmo	Marin	2	38	122.00	50	95	67	89	66	82	65	32	26			
San Antonio Canyon	Los Angeles	16	34.20	117.67	2394	100	68	96	67	90	65	33	29			
San Antonio Mission	Monterey	4	36	117.67	1060	99	69	94	68	88	67	28	19			
San Bernardino	San Bernardino	10	34.1	117.32	1125	106	70	102	69	98	68	39	27	1777		
San Bruno	San Mateo	3	37.7	122.42	20	86	66	80	64	73	62	23	30	3042		
San Carlos	San Mateo	3	37.5		26	92	67	88	65	82	63	28	28			
San Clemente	Orange	6	33.40	118.58	208	94	68	85	67	80	66	12	31			
San Diego AP	San Diego	7	32.70	117.17	13	88	70	83	69	78	68	13	38	1507		
San Dimas	Los Angeles	9	34		955	102	70	98	69	92	67	35	30			
San Fernando	Los Angeles	9	34.20	118.47	977	104	71	99	70	94	68	37	30	1800		
San Francisco AP	San Francisco	3	37.59	122.38	8	89	66	83	64	74	64	20	34	3042		
San Francisco CO	San Francisco	3	37.79	122.42	52	84	65	79	63	74	60	14	38	3080		
San Gabriel FD	Los Angeles	9	34.09	118.10	450	99	70	94	69	88	68	30	30	1532		
San Gregorio 2-SE	San Mateo	3	37.29		275	87	66	84	63	74	64	30	27			
San Jacinto	Riverside	10	33.79	116.97	1635	110	70	105	69	102	68	41	20	2376		
San Jose	Santa Clara	4	37.40	121.93	67	94	68	86	66	78	64	26	29	2438		
San Leandro	Alameda	3	37.70		45	89	67	83	64	76	62	22	28			
San Lorenzo	Alameda	3	37.70		45	89	67	83	64	76	62	23	28			
San Luis Dam	Merced	12	37.09		277	97	68	94	66	86	64	32	25			
San Luis Obispo	San Luis Obispo	5	35.29	120.72	320	94	63	87	63	81	62	26	30	2498		
San Marcos	San Diego	10	33.1		567	97	69	98	68	84	67	29	26			
San Marino	Los Angeles	9	34.20		300	100	69	95	68	88	66	28	30			
San Matee	San Mateo	3	37.5	122.30	24	92	67	84	65	76	63	24	34	2655		
San Nicholas Island	Ventura	6	33.20	119.47	504	85	66	78	65	70	64	11	39	2454		
San Pablo	Contra Costa	3	37.59		30	90	65	84	63	77	64	17	29			
San Pedro	Los Angeles	6	33.70	118.27	10	92	69	84	68	78	66	13	35	1819		
San Rafael	Marin	2	38	122.55	40	96	67	90	65	83	63	29	30	2440		
San Ramon	Contra Costa	12	37.7		360	99	69	93	67	86	65	35	24			

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							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Sandberg	Los Angeles	16	34.79	118.73	4517	95	63	94	61	87	59	32	17	4427		
Sanger	Fresno	13	36.70		364	105	72	101	70	96	68	37	24			
Santa Ana FS	Orange	8	33.79	117.83	115	98	70	94	68	84	67	26	33	1430		
Santa Barbara AP	Santa Barbara	6	34.40	119.83	9	90	69	83	67	77	65	20	29	2487		
Santa Barbara CO	Santa Barbara	6	34.40	119.68	5	91	69	84	67	78	65	22	33	1994		
Santa Clara Univ	Santa Clara	4	37.40	121.93	88	90	67	87	65	82	63	30	29	2566		
Santa Clarita	Los Angeles	9	34.4		1300	103	71	98	70	93	68	36	30			
Santa Cruz	Santa Cruz	3	37	122.02	125	94	68	88	66	84	64	28	27	3136		
Santa Fe Springs	Los Angeles	9	33.90		280	99	69	90	68	84	67	24	31			
Santa Maria AP	Santa Barbara	5	34.90	120.45	236	99	66	83	64	78	64	23	25	3053		
Santa Monica	Los Angeles	6	34	118.50	15	85	67	78	66	72	64	15	39	1873		
Santa Paula	Ventura	9	34.40		263	101	71	94	70	87	68	28	28	2030		
Santa Rosa	Sonoma	2	38.5	122.82	167	99	69	96	68	92	66	35	24	2980		
Santee	San Diego	10	32.79		400	96	69	94	68	87	67	20	25			
Saratoga	Santa Clara	4	37.29		500	96	67	88	66	80	65	34	27			
Sausalito	Sonoma	3	37.90		10	85	66	80	65	73	63	12	30			
Sawyer's Bar RS	Siskiyou	16	41.29		2169	100	66	95	65	88	62	38	14	4102		
Scotia	Humboldt	4	40.5	124.37	139	78	61	74	60	69	58	19	28	3954		
Scotts Valley	Santa Cruz	3	37		400	94	68	88	66	84	64	28	27			
Seal Beach	Orange	6	33.79	119.08	24	94	69	86	68	80	65	15	36	1519		
Seaside	Monterey	4	36.59		47	85	66	79	64	73	62	20	30			
Sebastopol	Sonoma	2	38.4		102	99	69	96	68	92	66	35	24			
Selma	Fresno	13	36.59		305	104	73	101	71	97	68	38	24			
Sepulveda	Los Angeles	9	34.2		818	103	71	98	69	92	67	32	28			
Shafter	Kern	13	35.5	119.17	345	106	71	102	70	98	68	28	24	2185		
Shasta Dam	Shasta	16	40.70		1076	105	69	101	68	95	67	27	29	2943		
Shelter Cove	Humboldt	4	40	124.07	110	80	61	73	60	68	57	15	34			
Sherman Oaks	Los Angeles	9	34.2		667	103	71	98	69	92	67	28	29			
Sierra City	Sierra	16	39.59	120.12	4230	96	62	93	61	89	59	43	12			
Sierra Madre	Los Angeles	9	34.20		1153	102	69	96	68	90	67	27	32			
Sierraville RS	Sierra	16	39.59	120.37	4975	94	60	94	59	86	57	44	10	6893		
Signal Hill	Los Angeles	6	33.5		100	99	70	90	69	84	66	19	35			
Simi Valley	Ventura	9	34.40		500	98	70	93	68	87	66	30	28			
Solana Beach	San Diego	7	33		15	87	68	83	67	77	65	10	35			
Soledad	Monterey	3	36.4		200	90	67	87	65	82	64	23	24			
Sonoma	Sonoma	2	38.29		70	101	70	96	69	90	67	40	22	2998		
Sonora RS	Tuolumne	12	38	120.38	1749	103	68	100	67	95	66	34	20	3537		
Sequel	Santa Cruz	3	37		50	94	67	88	66	84	63	24	27			
South El Monte	Los Angeles	9	34		270	101	72	97	70	91	68	28	31			
South Entr Yosemite	Tuolumne	16	37.5	119.63	5120	92	61	88	60	84	59	36	8	5789		
South Gate	Los Angeles	8	33.90		120	97	70	90	69	84	67	21	32			
South Laguna	Orange	6	33.6		100	91	69	83	68	78	66	18	30			
South Lake Tahoe	El Dorado	16	38.90		6200	85	56	82	55	74	54	33	-2			
South Oroville	Butte	14	39.5		174	106	71	104	70	98	69	37	25			
South Pasadena	Los Angeles	9	34		657	99	69	94	68	88	67	30	31			
South San Francisco	San Mateo	3	37.70		10	87	67	81	64	72	62	20	32			
South San Gabriel	Los Angeles	9	34.1		450	99	70	94	69	88	68	73	30			
South Whittier	Los Angeles	9	33.90		300	100	70	92	69	84	68	30	31			
South Yuba City	Sutter	14	39.4		59	105	69	101	69	96	68	36	24			
Spring Valley	San Diego	10	32.70		300	94	69	86	68	82	66	30	34			

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						0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Squaw Valley	Placer	16	39.20		6235	88	57	85	56	80	54	40	-10		
Squirrel Inn	San Bernardino	14	34.20	117.23	5680	86	61	82	60	77	58	23	12	5175	
Stanford	Santa Clara	4	37.5		23	93	66	85	64	77	62	25	26		
Stanton	Orange	8	33.59		45	98	69	91	68	84	67	24	31		
Stockton AP	San Joaquin	12	37.90	121.25	22	103	71	98	69	93	67	35	24	2806	
Stockton FS-4	San Joaquin	12	38	121.32	42	101	70	96	68	91	67	37	24	2846	
Stony Gorge Res	Glenn	14	39.59	122.53	794	104	70	99	69	93	67	37	21	3149	
Strawberry Valley	Tuolumne	16	39.59		3808	96	63	93	62	88	60	32	14	5120	
Studio City	Los Angeles	9	34.28	118.39	620	102	70	97	69	91	67	31	28		
Suisun City	Solano	12	38.2		72	103	71	98	69	91	66	35	24		
Sun City	Riverside	10	33.7		1420	105	70	101	69	97	68	39	22		
Sunland	Los Angeles	9	34.29		1460	107	71	102	70	96	68	36	28		
Sunnyvale	Santa Clara	4	37.29	122.03	97	96	68	88	66	80	64	26	29	2511	
Susanville AP	Lassen	16	40.40	120.57	4148	98	62	95	61	90	59	38	4	6233	
Taft	Kern	13	35.1		987	106	71	102	70	98	68	34	26		
Tahoe City	Placer	16	39.20	120.13	6230	84	56	84	55	76	53	36	2	8085	
Tahoe Valley AP	Placer	16	38.90		6254	85	56	82	55	77	53	38	5		
Tamalpais-Homestead Valley	Marin	3	37.9		25	97	68	94	66	84	64	28	28		
Tarzana	Los Angeles	6	34.18	118.55	800	104	71	99	69	93	68	27	27		
Tehachapi	Kern	16	35.09		3975	97	66	93	65	89	64	33	43	4494	
Telion Rancho	Los Angeles	16	35	118.75	1425	107	71	103	70	99	68	27	24	2602	
Temecula	Riverside	10	33.5		1006	101	69	96	68	94	67	34	24		
Temple City	Los Angeles	9	34.09		403	101	70	95	69	89	68	27	30		
Terme	Los Angeles	16	40.90		5300	95	60	92	59	87	57	37	17		
Thermal AP	Riverside	15	33.59		1112	114	74	110	74	106	74	29	26	1154	
Thermalito	Butte	14	37.9		25	106	71	104	70	98	69	37	25		
Thousand Oaks	Ventura	9	34.20		810	98	69	93	68	88	67	30	27		
Three Rivers PH 1	Tulare	13	36.5		1140	105	70	102	69	98	67	38	24	2642	
Tiburon	Marin	3	37.90		90	85	66	80	65	73	63	12	30		
Tiger Creek PH	Amador	12	38.5	120.48	2355	100	66	96	55	92	63	36	20	3795	
Torrance	Los Angeles	6	33.79	118.33	110	93	69	86	68	80	66	18	32	1859	
Tracy Carbona	San Joaquin	12	37.70		140	102	70	97	68	90	67	38	24	2704	
Tracy Pumps	San Joaquin	12	37.79		61	104	71	99	69	92	68	39	23		
Travis AFB	Sonoma	12	38.29	121.93	72	103	71	98	69	94	66	35	24	2725	
Trinity Dam	Trinity	16	40.79		2500	99	65	94	64	88	62	37	17		
Trona	San Bernardino	14	35.79	117.38	1695	113	72	109	70	105	68	35	18	2415	
Truckee RS	Nevada	16	39.29	120.18	5995	90	58	87	57	82	55	40	-10	8230	
Tujunga	Los Angeles	9	34.29		1820	103	70	99	69	94	67	36	20		
Tulare	Tulare	13	36.20		290	105	72	101	71	96	69	39	24		
Tulelake	Siskiyou	16	42		4035	92	60	88	59	83	57	41	5	6854	
Turlock	Stanislaus	12	37.5		100	104	72	100	70	95	68	40	24		
Turntable Creek	Plumas	16	40.79		1067	105	69	101	68	95	66	28	24		
Tustin Foothills	Orange	8	33.8		500	99	71	92	69	85	68	27	28		
Tustin-Irvine Rch	Orange	8	33.70	117.78	118	99	71	92	69	85	68	27	28	4856	
Twenty-nine Palms	San Bernardino	14	34.09	116.05	1975	110	71	107	70	103	69	34	21	1973	
Twin Lakes	Mono	16	38.70		7829	73	49	64	47	57	46	30	7	9196	
Twitchell Dam	San Luis Obispo	5	35		582	99	70	93	68	88	66	26	26		
UCLA	Los Angeles	9	34.09		430	93	69	86	68	80	66	20	39	1509	
Ukiah	Mendocino	2	39.20	123.20	623	100	70	97	69	92	68	42	22	2958	

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							0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Union City	Alameda	3	37.6		5	90	67	87	66	81	63	20	25			
Upland	San Bernardino	10	34.1		1605	102	69	98	68	92	66	31	29	2175		
Upper Lake RS	Lake	2	39.20	122.95	1347	98	68	95	67	91	64	39	18			
Upper San Leandro	Alameda	3	37.70		394	93	67	87	66	80	63	22	28			
Vacaville	Solano	12	38.40		405	103	71	100	70	94	68	40	23	2788		
Valinda	Los Angeles	9	34		340	102	70	98	69	92	68	28	34			
Valle Vista	Riverside	10	33.8		1655	109	70	104	69	101	67	40	20			
Vallejo	Solano	3	38.00		85	93	67	90	66	84	64	23	28			
Valvermo RS	Los Angeles	14	34.5		3600	100	67	96	66	91	65	41	12	3870		
Van Nuys	Los Angeles	9	34.2		708	103	71	98	69	92	67	30	28			
Vandenberg AFB	Santa Barbara	5	34.70	122.80	368	85	62	77	64	71	60	16	30	3451		
Ventura	Ventura	6	34.20		341	89	68	82	67	76	66	15	29			
Victorville Pumps	San Bernardino	14	34.5		2858	105	67	101	65	97	62	39	44	3191		
View Park	Los Angeles	6.8	34		300	95	69	88	68	78	66	18	36			
Villa Park	Orange	8	33.8		300	99	70	92	68	85	67	27	33			
Vincent	Los Angeles	14	34.5		3135	105	67	101	65	96	64	33	10			
Visalia	Tulare	13	36.20		325	103	71	100	70	96	69	38	25	2450		
Vista	San Diego	7	33.20		510	96	69	90	68	85	67	16	30			
Volta PH	Merced	12	40.5		2220	101	66	98	65	93	63	33	24			
Walnut	Los Angeles	9	34		550	101	70	97	69	92	69	30	28			
Walnut Creek	Contra Costa	12	37.90		245	100	69	94	67	87	66	32	23			
Walnut Grove	Sacramento	12	38.20		23	102	70	98	69	92	68	37	24			
Walnut Park	Los Angeles	8	33.9		45	92	69	84	68	78	66	12	37			
Warner Springs	San Diego	14	33.20		3100	100	67	95	66	91	65	40	15	3501		
Wasco	Kern	13	35.59		333	105	71	101	70	97	68	36	23	2466		
Watsonville	Santa Cruz	3	36.00		95	86	66	82	64	79	64	22	28	3418		
Weaverville RS	Trinity	16	40.70		2050	100	67	95	66	89	63	46	10	4992		
Weed FD	Siskiyou	16	41.40		3500	92	63	89	62	84	59	35	4			
West Athens	Los Angeles	8	33.9		25	92	69	85	68	80	66	18	32			
West Carson	Los Angeles	6	33.70		100	92	69	87	68	81	66	18	32			
West Compton	Los Angeles	8	33.9		71	97	69	90	68	83	67	24	33			
West Covina	Los Angeles	9	34		365	102	70	98	69	92	68	34	29			
West Hollywood	Los Angeles	9	34		290	95	70	89	69	82	67	20	38			
West Pittsburg	Contra Costa	12	38		42	102	70	97	68	90	67	34	26			
West Puente Valley	Los Angeles	9	34	117.93	500	101	71	97	70	94	68	26	34			
West Sacramento	Yolo	12	38.6		49	104	72	100	70	94	68	35	26			
West Whittier Los	Los Angeles	9	34		320	99	69	90	68	84	67	24	34			
Westlake Village	Los Angeles	9	34.2		750	103	71	99	70	94	69	26	26			
Westminster	Orange	6	33.70		38	95	70	88	68	81	67	23	33			
Westmont	Los Angeles	8	33.9		110	96	70	89	69	83	67	20	36			
Whiskeytown Res	Shasta	11	40.59		1295	105	69	101	68	96	67	34	25			
White Mtn-1	Mono	16	37.5		1015	73	49	69	47	65	45	37	-15			
White Mtn-2	Mono	16	37.59		1247	64	42	58	44	54	40	38	-20			
Whittier	Los Angeles	9	34		320	99	69	90	68	84	67	24	34			
Wildomar	Riverside	10	33.6		1255	103	70	99	69	94	68	36	23			
Wildrose RS	Inyo	16	36.20		4100	100	64	97	63	93	64	33	13			
Williams	Colusa	11	39.20		85	104	71	100	70	94	68	36	24			
Willits	Mendocino	2	39.40	123.32	1350	95	66	89	65	82	62	38	18			
Willow Brook	Los Angeles	8	33.90		60	97	70	90	69	83	67	24	35			
Willow Creek	Humboldt	2	41	123	461	104	70	98	68	92	66	35	22			

City	County	Climate Zone	Latitude	Longitude	Elevation	SUMMER								Winter Median of Extremes	HDD*
						0.1% Dry Bulb	0.1% Wet Bulb	0.5% Dry Bulb	0.5% Wet Bulb	2% Dry Bulb	2% Wet Bulb	Out door Daily Range			
Willows	Colusa	11	39.5		140	104	71	100	70	94	68	36	22	2836	
Windsor	Sonoma	2	38.5		130	99	69	96	68	92	66	35	24		
Winters	Yolo	12	38.5		135	104	71	99	70	93	68	38	24	2593	
Winton	Merced	12	37.4		168	103	71	100	69	95	67	36	24		
Woodcrest	Riverside	10	33.9		1500	104	70	100	69	95	65	37	27		
Woodfords	Alpine	16	38.79		5671	92	59	89	58	84	56	32	0	6047	
Woodlake	Tulare	13	36.3		500	103	71	100	70	96	69	38	25		
Woodland	Yolo	12	38.70		69	106	72	101	71	96	69	40	25	2708	
Woodland Hills	Los Angeles	9	34.2		944	104	71	99	70	93	68	32	26		
Woodside	San Mateo	3	37.5		75	92	67	84	66	76	63	24	22		
Yerba Linda	Orange	8	33.90		350	102	70	94	69	88	68	34	30	1643	
Yosemite Park Ha	Mariposa	16	37.70		3970	97	63	94	62	90	60	38	14	4785	
Yreka	Siskiyou	16	41.70		2625	99	66	95	65	90	64	39	8	5395	
Yuba City	Sutter	14	39.09		70	105	69	101	69	96	68	36	24		
Yucaipa	San Bernardino	10	34		2600	106	68	102	67	98	65	35	27		
Yucca Valley	San Bernardino	14	34.2		2600	108	71	105	70	101	69	32	19		

***Heating Degree Day** is a unit, based on temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day when the mean temperature is less than 65°F (18°C), there exist as many degree days as there are Fahrenheit degrees difference in temperature between mean temperature for the day and 65°F (18°C).

ACM ND-2005

Appendix ND - Compliance Procedures for Relocatable Public School Buildings

ND.1 Purpose and Scope

This document describes the compliance procedures that shall be followed when the whole building performance approach is used for relocatable public school buildings. Relocatable public school buildings are constructed (manufactured) at a central location and could be shipped and installed in any California climate zone. Furthermore, once they arrive at the school site, they could be positioned so that the windows face in any direction. The portable nature of relocatable classrooms requires that a special procedure be followed for showing compliance when the whole building performance method is used. Compliance documentation for relocatable public school buildings will be reviewed by the Division of the State Architect.

ND.2 The Plan Check Process

The Division of the State Architect (DSA) is the building department for relocatable public school buildings. Since relocatables are manufactured in batches, like cars or other manufactured products, the plan check and approval process occurs in two phases. The first phase is when the relocatable manufacturer completes design of a model or modifies a model. At this point, complete plans and specifications are submitted to the DSA; DSA reviews the plans for compliance with the energy standards and other California Building Code (CBC) requirements; and a "pre-check" (PC) design approval is granted. Once the PC design is approved, a school district or the manufacturer may file an "over-the-counter" application with DSA to construct one or more relocatables. The over-the-counter application is intended to be reviewed quickly, since the PC design has already been pre-checked. The over-the-counter application is the building permit application for construction and installation of a relocatable at a specific site, and includes the approved PC design drawings as well as site development plans for the proposed site where the relocatable will be installed. An over-the-counter application also is required for the construction of a stockpile of one or more relocatables based on the approved PC design drawings. Stockpiled relocatables are stored typically at the manufacturer's yard until the actual school site is determined where the relocatable will be installed. Another over-the-counter application is required to install a previously stockpiled relocatable at which time site development plans for the proposed site are checked.

The effective date for all buildings subject to the energy standards is the date of permit application. If a building permit application is submitted on or after the effective date, then the new energy standards apply. For relocatable classrooms, the date of the permit application is the date of the over-the-counter application, not the date of the application for PC design approval. The PC design is only valid until the code changes.

ND.3 The Compliance Process

Like other nonresidential buildings, the standard design for relocatable public school buildings is defined by the prescriptive requirements. In the case of relocatables, there are two choices of prescriptive criteria:

- Table 143-C in the Standards may be used for relocatable school buildings that can be installed in any climate zone in the state. In this case, the compliance is demonstrated in climates 14, 15, and 16 and this is accepted as evidence that the classroom will comply in all

climate zones. These relocatables will have a permanent label that allows it to be used anywhere in the state.

- Table 143-A in the Standards may be used for relocatable school buildings that are to be installed in only specific climate zones. In this case, compliance is demonstrated in each climate zone for which the relocatable has been designed to comply. These relocatables will have a permanent label that identifies in which climate zones it may be installed. It is not lawful to install the relocatable in other climate zones.

The building envelope of the standard design has the same geometry as the proposed design, including window area and position of windows on the exterior walls, and meets the prescriptive requirements specified in §143. Lighting power for the standard design meets the prescriptive requirements specified in §146. The HVAC system for the standard design meets the prescriptive requirements specified in §144. The system typically installed in relocatables is a single-zone packaged heat pump or furnace. Most relocatable school buildings do not have water heating systems, so this component is neutral in the analysis. Other modeling assumptions such as equipment loads, are the same for both the proposed design and the standard design and are specified in the Nonresidential ACM Manual.

Manufacturers shall certify compliance with the standards and all compliance documentation shall be provided. If the manufacturer chooses to comply using Table 143-A for compliance in only specific climate zones, then the manufacturers shall indicate the climates zones for which the classroom will be allowed to be located.

Since relocatable public school buildings could be positioned in any orientation, it is necessary to perform compliance calculations for multiple orientations. Each model with the same proposed design energy features shall be rotated through 12 different orientations either in climate zones 14, 15 and 16 for relocatables showing statewide compliance or in the specific climate zones that the manufacturer proposes for the relocatable to be allowed to be installed, i.e., the building with the same proposed design energy features is rotated in 30 degree increments and shall comply in each case. Approved compliance programs shall automate the rotation of the building and reporting of the compliance results to insure it is done correctly and uniformly and to avoid unnecessary documentation.

ND.4 Documentation

The program shall present the results of the compliance calculations in a format similar to Table ND-15. For each of the cases (12 orientations times number of climates), the Time Dependent Valuation (TDV) energy for the *Standard Design* and the *Proposed Design* are shown (the energy features of the *Proposed Design* shall be the same for all orientations). The final column shows the compliance margin, which is the difference between the TDV energy for the *Proposed Design* and the *Standard Design*. Approved compliance programs shall scan the data presented in the Table ND-15 format and prominently highlight the case that has the smallest compliance margin. Complete compliance documentation shall be submitted for the building and energy features that achieve compliance in all of the climate zones and orientations as represented by the case with the smallest margin. DSA may require that compliance documentation for other cases also be submitted; showing that the *Proposed Design* building and energy features are identical to the case submitted, in each orientation and climate zone. Table ND-15 shows rows for climate zones 14, 15, and 16, which are the ones used when the criteria of Table 143-C is used to show compliance throughout the state. If the criteria of Table 143-A is used, then rows shall be added to the table for each climate zone for which the manufacturer wants the relocatable to be allowed to be installed.

Table ND-15 – Summary of Compliance Calculations Needed for Relocatable Classrooms

<u>Climate Zone</u>	<u>Azimuth</u>	<u>TDV Energy</u>		
		<u>Proposed Design</u>	<u>Standard Design</u>	<u>Compliance Margin</u>
<u>14</u>	<u>0</u>			
	<u>30</u>			
	<u>60</u>			
	<u>90</u>			
	<u>120</u>			
	<u>150</u>			
	<u>180</u>			
	<u>210</u>			
	<u>240</u>			
	<u>270</u>			
	<u>300</u>			
<u>15</u>	<u>0</u>			
	<u>30</u>			
	<u>60</u>			
	<u>90</u>			
	<u>120</u>			
	<u>150</u>			
	<u>180</u>			
	<u>210</u>			
	<u>240</u>			
	<u>270</u>			
	<u>300</u>			
<u>16</u>	<u>0</u>			
	<u>30</u>			
	<u>60</u>			
	<u>90</u>			
	<u>120</u>			
	<u>150</u>			
	<u>180</u>			
	<u>210</u>			
	<u>240</u>			
	<u>270</u>			
	<u>300</u>			
<u>330</u>	<u>330</u>			

ND.5 Optional Features

Relocatable classrooms may come with a variety of optional features, like cars. A school district can buy the “basic model” or it can pay for options. Many of the optional features do not affect energy efficiency and are not significant from the perspective of energy code compliance. Examples include floor finishes (various grades of carpet or tiles), casework, and ceiling and wall finishes. Other optional features do affect energy performance such as window construction.

insulation, lighting systems, lighting controls, HVAC ductwork, HVAC equipment, and HVAC controls.

When a manufacturer offers a relocatable classroom model with a variety of options, it is necessary to identify those options that affect energy performance and to show that the model complies with any combination of the optional features. Most of the time, optional energy features are upgrades that clearly improve performance. If the basic model complies with the Standards, then adding any or all of the optional features would improve performance. The following are examples of optional features that are clear upgrades in terms of energy performance:

- HVAC equipment that has both a higher SEER and higher EER than the equipment in the basic model.
- Lighting systems that result in less power than the basic model.
- Lighting controls, such as occupancy sensors, that are recognized by the standards and for which power adjustment factors in Table 146-B are published in §146 of the Standards.
- Windows that have both a lower SHGC and lower U-factor (limited to relocatables that do not take credit for daylighting).
- Wall, roof or floor construction options that result in a lower U-factor than the basic model.

For energy code compliance purposes, it is necessary to show that every variation of the relocatable classroom that is offered to customers will comply with the Standards. There are two approaches for achieving this, as defined below:

1) Basic Model Plus Energy Upgrades Approach The simplest approach is to show that the basic model complies with the Standards and that all of the options that are offered to customers are clear energy upgrades that would only improve performance. As long as each and every measure in the basic model is met or exceeded by the energy upgrades, the relocatable classroom will comply with the standards.

While clear upgrades are obvious in most cases, the following are some examples of options that are not energy upgrades, for which additional analysis would be needed to show compliance that every combination of options comply.

- HVAC equipment that has a higher SEER, but a lower EER.
- Windows that lower SHGC but increase U-factor, or vice versa.
- Insulation options that reduce the U-factor for say walls, but increase it for the roof.
- Any other combination of measures that results in the performance of anyone measure being reduced in comparison to a complying basic model.

2) Modeling of Every Combination Approach. A more complex whole building performance approach is required when a model is available with options which in combination may or may not comply. In this case every combination of options shall be modeled, and the specific combinations that comply shall be determined and only those combinations shall be allowed. This approach, while possible, requires considerably more effort on the part of the relocatable manufacturer and its energy consultant. It also places a greater burden on DSA when they issue the over-the-counter building permit for the PC design that only allows specific combinations of energy options.. DSA would have to examine the specific optional features that are proposed with the over-the-counter application and make sure that the proposed combination of measures achieves compliance.

The manufacturer or its energy consultant would need to prepare a table or chart that shows all of the acceptable combinations that achieve compliance. This chart could be quite complex, depending on the number of optional features that are offered.

Table ND-16 is intended to illustrate the complexity that could be involved in modeling of every combination of energy features. It shows a list of typical optional features that would affect

energy performance. In this example, there are two possible for each of the eight options, e.g. the feature is either there or not (in an actual case there could be a different number of options and a different number of states for any option). In the example any one of the features could be combined with any of the others. The number of possible combinations in this example is two (the number of states) to the eighth power (the number of measures that have two states). The number of possible options is then 2^8 or 256. This is the number of combinations that would need to be modeled in order to determine which combinations of optional features achieves compliance.

Table ND-16 – Examples of Optional Features for Relocatable Classrooms

Options Offered	States
1 Efficient lighting option	Yes/N o
2 High efficiency heat pump	Yes/N o
3 Improved wall insulation	Yes/N o
4 Improved roof insulation	Yes/N o
5 Occupancy sensor for lighting	Yes/N o
6 Low-e windows	Yes/N o
7 Skylights	Yes/N o
8 Daylighting Controls	Yes/N o

Appendix D:

Glossary

Appendix D: Definitions

Terms, phrases, words, and their derivatives in Part 6 of the California State Building Code shall be defined as specified in Section 101 of that Code. Terms, phrases, words, and their derivatives not found in Section 101 shall be defined as specified in Title 24, Part 2, Chapter 2-4 of the California Code of Regulations. Terms, phrases, words, and their derivatives not found in either Title 24, Part 6 or Chapter 2-4 shall be defined as specified in Part II, Chapter 4 of the Uniform Building Code. Where terms, phrases, words, and their derivatives are not defined in any of the references above, they shall be defined as specified in Webster's Third New International Dictionary of the English Language, Unabridged (1987 ed.), unless the context requires otherwise.

ACCA is the Air Conditioning Contractors of America.

ACCESSIBLE is having access thereto, but which first may require removal or opening of access panels, doors, or similar obstructions.

ADDITION is any change to a building that increases conditioned floor area and conditioned volume.

AIR TO AIR HEAT EXCHANGER is a device which will reduce the heat losses or gains which occur when a building is mechanically ventilated, by transferring heat between the conditioned air being exhausted and the unconditioned air being supplied.

ALTERATION is any change to a building's water heating system, space conditioning system, lighting system, or envelope that is not an addition. **ALTERNATIVE CALCULATION METHODS (ACMs)** are the Commission's Public Domain Computer Programs, one of the Commission's Simplified Calculation Methods, or any other calculation method approved by the Commission.

ALTERNATIVE CALCULATION METHOD (ACM) is a calculation method used to determine compliance with the building energy efficiency standards other than the reference method which (for the nonresidential building standards) uses the reference computer program, DOE 2.1E, as the computational engine. The current requirements limit ACMs to computer programs since there are specific requirements in this manual for required inputs, automated restrictive outputs, and automatic default assumptions.

ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE) is a measure of the percentage of heat from the combustion of gas or oil which is transferred to the space being heated during a year, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

ANNUNCIATED is a visual signaling device that indicates the on, off, or other status of a load.

ANSI is the American National Standards Institute.

APPLIANCE EFFICIENCY REGULATIONS are the regulations in Title 20, Sections 1601 et seq. of the California Code of Regulations.

APPROVED BY THE COMMISSION means approval under Section 25402.1 of the Public Resources Code.

APPROVED CALCULATION METHOD (See ALTERNATIVE CALCULATION METHODS).

ARI is the Air conditioning and Refrigeration Institute.

ASHRAE is the American Society of Heating, Refrigerating, and Air-conditioning Engineers.

ASME is the American Society of Mechanical Engineers.

ASTM is the American Society for Testing and Materials.

atrium is an opening through two or more floor levels other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air conditioning, or other equipment which is enclosed space and not defined as a mall.

ATTIC is an enclosed unconditioned space directly below the roof and above the ceiling.

AUTOMATIC is capable of operating without human intervention.

AUTOMATIC TIME SWITCH CONTROL DEVICES are devices capable of automatically turning loads off and on based on time schedules.

BELOW GRADE WALL is the portion of a wall, enclosing conditioned space, that is below the grade line.

BUILDING is any structure or space for which a permit is sought.

BUILDING ENVELOPE is the ensemble of exterior and demising partitions of a building that enclose conditioned space.

CAPTIVE KEY OVERRIDE is a type of lighting control in which the key that activates the override cannot be released when the lights are in the on position.

CEILING is the interior upper surface of a space separating it from the attic, which has a slope less than 60 degrees from horizontal.

CERTIFYING ORGANIZATION is an independent organization recognized by the Commission to certify manufactured devices for performance values in accordance with procedures adopted by the Commission.

CLIMATE CONTROL SYSTEM (See SPACE CONDITIONING SYSTEM).

CLIMATE ZONES are the 16 geographic areas of California for which the Commission has established typical weather data, prescriptive packages and energy budgets. Climate zone boundary descriptions are in the document "California Climate Zone Descriptions" (July 1995), incorporated herein by reference. Figure 1-A is an approximate map of the 16 climate zones.

CMC means the 1998 California Mechanical Code prior to the effective date designated by the California Building Standards Commission for the 2000 California Mechanical Code. On and after the effective date designated by the California Building Standards Commission for the 2000 California Mechanical Code, CMC shall mean the 2000 California Mechanical Code.

COEFFICIENT OF PERFORMANCE (COP), COOLING, is the ratio of the rate of net heat removal to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

COEFFICIENT OF PERFORMANCE (COP), HEATING, is the ratio of the rate of net heat output to the rate of total energy input, calculated under designated operating conditions and expressed in consistent units, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

COMMISSION is the California State Energy Resources Conservation and Development Commission.

COMPLETE BUILDING is an entire building with one occupancy making up 90 percent of the conditioned floor area (see also ENTIRE BUILDING).

CONDITIONED FLOOR AREA (CFA) is the floor area (in square feet) of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces of exterior walls enclosing the conditioned space.

CONDITIONED SPACE is space in a building that is either directly conditioned or indirectly conditioned.
CONDITIONED VOLUME is the total volume (in cubic feet) of the conditioned space within a building.

CONSTRUCTION LAYERS are layers of material that make up a construction assembly.

COOL ROOF is a roofing material with high solar reflectance and high emittance that reduces heat gain through the roof.

COOLING EQUIPMENT is equipment used to provide mechanical cooling for a room or rooms in a building.

COURTYARD is an open space through one or more floor levels surrounded by walls within a building.

COVERED PRODUCT is an appliance regulated by the efficiency standards established under the National Appliance Energy Conservation Act, 42 U.S.C. Section 6291 et seq.

CRAWL SPACE is a space immediately under the first floor of a building adjacent to grade.

CTI is the Cooling Tower Institute.

C-VALUE (also known as C-FACTOR) is the time rate of heat flow through unit area of a body induced by a unit temperature difference between the body surfaces, in Btu/hr ft² °F. It is not the same as K-value or K-factor.

DAYLIT AREA is the space on the floor that is the larger of (a) plus (b), or (c):

- (a) For areas daylit by vertical glazing, the daylit area has a length of 15 feet, or the distance on the floor, perpendicular to the glazing, to the nearest 60-inch or higher opaque partition, whichever is less; and a width of the window plus either 2 feet on each side, the distance to an opaque partition, or one-half the distance to the closest skylight or vertical glazing, whichever is least.
- (b) For areas daylit by horizontal glazing, the daylit area is the footprint of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of the floor-to-ceiling height, the distance to the nearest 60-inch or higher opaque partition, or one-half the horizontal distance to the edge of the closest skylight or vertical glazing.
- (c) The daylit area calculated using a method approved by the Commission.

DECORATIVE GAS APPLIANCE is a gas appliance that is designed or installed for visual effect only, cannot burn solid wood, and simulates a fire in a fireplace.

DEGREE DAY, HEATING is a unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day, when the mean temperature is less than 65°F, there exist as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65°F. The number of degree days for specific geographical locations are those listed in the Residential Manual. For those localities not listed in the Residential Manual the number of degree days is as determined by the applicable enforcing agency.

DEMISING PARTITIONS are barriers that separate conditioned space from enclosed unconditioned space.

DEMISING WALL is a wall that is a demising partition.

DENSITY is the mass per unit volume of a construction material as documented in an ASHRAE handbook, a comparably reliable reference or manufacturer's literature.

DESIGN CONDITIONS are the parameters and conditions used to determine the performance requirements of space conditioning systems. Design conditions for determining design heating and cooling loads are specified in Section 144(b) for nonresidential, high rise residential, and hotel/motel buildings and in Section 150(h) for low rise residential buildings.

DESIGN HEAT GAIN RATE is the total calculated heat gain through the building envelope under design conditions.

DESIGN HEAT LOSS RATE is the total calculated heat loss through the building envelope under design conditions.

DIRECTLY CONDITIONED SPACE is an enclosed space that is provided with wood heating, is provided with mechanical heating that has a capacity exceeding 10 Btu/hr ft², or is provided with mechanical cooling that has a capacity exceeding 5 Btu/hr ft², unless the space conditioning system is designed and thermostatically controlled to maintain a process environment temperature less than 55°F or to maintain a process environment temperature greater than 90°F for

the whole space that the system serves, or unless the space conditioning system is designed and controlled to be incapable of operating at temperatures above 55°F or incapable of operating at temperatures below 90°F at design conditions.

DISPLAY LIGHTING is lighting confined to the area of a display that provides a higher level of illuminance than the level of surrounding ambient illuminance.

DISPLAY PERIMETER is the length of an exterior wall in a B, F-1, or M occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk.

DISPLAY, PUBLIC AREA are areas for the display of artwork, theme displays, and architectural surfaces in dining and other areas of public access, excluding restrooms and separate banquet rooms.

DISPLAY, SALES FEATURE is an item or items that requires special highlighting to visually attract attention and that is visually set apart from the surrounding area.

DISPLAY, SALES FEATURE FLOOR is a feature display in a retail store, wholesale store, or showroom that requires display lighting.

DISPLAY, SALES FEATURE WALL are the wall display areas, in a retail or wholesale space, that are in the vertical plane of permanent walls or partitions, and that are open shelving feature displays or faces of internally illuminated transparent feature display cases within the Gross Sales Wall Area.

DUAL GLAZED GREENHOUSE WINDOWS are a type of dual glazed fenestration product which adds conditioned volume but not conditioned floor area to a building.

DUCT SEALING is a procedure for installing a space conditioning distribution system that minimizes leakage of conditioned air. Minimum specifications for installation procedures, materials, diagnostic testing and field verification are contained in the Residential and Nonresidential ACM Approval Manuals.

EAST-FACING is oriented to within 45 degrees of true east, including 45°00'00" south of east (SE), but excluding 45°00'00" north of east (NE).

ECONOMIZER, AIR is a ducting arrangement and automatic control system that allows a cooling supply fan system to supply outside air to reduce or eliminate the need for mechanical cooling.

ECONOMIZER, WATER is a system by which the supply air of a cooling system is cooled directly or indirectly by evaporation of water, or other appropriate fluid, in order to reduce or eliminate the need for mechanical cooling.

EFFECTIVE APERTURE (EA) is (1) for windows, the visible light transmittance (VLT) times the window wall ratio; and (2) for skylights, the well index times the VLT times the skylight area times 0.85 divided by the gross exterior roof area.

EFFICACY is the ratio of light from a lamp to the electrical power consumed (including ballast losses), expressed in lumens per watt.

ENCLOSED SPACE is space that is substantially surrounded by solid surfaces.

ENERGY BUDGET is the maximum amount of source energy that a proposed building, or portion of a building, can be designed to consume, calculated with the approved procedures specified in Title 24, Part 6.

ENERGY EFFICIENCY RATIO (EER) is the ratio of net cooling capacity (in Btu/hr) to total rate of electrical energy (in watts), of a cooling system under designated operating conditions, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

ENERGY FACTOR (EF) is the ratio of energy output to energy consumption of a water heater, expressed in equivalent units, under designated operating conditions over a 24 hour use cycle, as determined using the applicable test method in the Appliance Efficiency Regulations.

ENERGY OBTAINED FROM DEPLETABLE SOURCES is electricity purchased from a public utility, or any energy obtained from coal, oil, natural gas, or liquefied petroleum gases.

ENERGY OBTAINED FROM NONDEPLETABLE SOURCES is energy that is not energy obtained from depletable sources.

ENFORCING AGENCY is the city, county, or state agency responsible for issuing a building permit.

ENTIRE BUILDING is the ensemble of all enclosed space in a building, including the space for which a permit is sought, plus all existing conditioned and unconditioned space within the structure.

ENVELOPE means BUILDING ENVELOPE.

EXFILTRATION is uncontrolled outward air leakage from inside a building, including leakage through cracks and interstices, around windows and doors, and through any other exterior partition or duct penetration.

EXTERIOR DOOR is a door through an exterior partition that is opaque or has a glazed area that is less than or equal to one half of the door area. Doors with a glazed area of more than one half of the door area are treated as a fenestration product.

EXTERIOR FLOOR/SOFFIT is a horizontal exterior partition, or a horizontal demising partition, under conditioned space. For low rise residential occupancies, exterior floors also include those on grade.

EXTERIOR PARTITION is an opaque, translucent, or transparent solid barrier that separates conditioned space from ambient air or space that is not enclosed. For low rise residential occupancies, exterior partitions also include barriers that separate conditioned space from unconditioned space, or the ground.

EXTERIOR ROOF/CEILING is an exterior partition, or a demising partition, that has a slope less than 60 degrees from horizontal, that has conditioned space below, and that is not an exterior door or skylight.

EXTERIOR ROOF/CEILING AREA is the area of the exterior surface of exterior roof/ceilings.

EXTERIOR WALL is any wall or element of a wall, or any member or group of members, which defines the exterior boundaries or courts of a building and which has a slope of 60 degrees or greater with the horizontal plane. An exterior wall or partition is not an exterior floor/soffit, exterior door, exterior roof/ceiling, window, or skylight, or demising wall.

EXTERIOR WALL AREA is the area of the opaque exterior surface of exterior walls.

FENESTRATION PRODUCT is any transparent or translucent material plus any sash, frame, mullions, and dividers, in the envelope of a building, including, but not limited to: windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one half of the door area.

FENESTRATION SYSTEM means a collection of fenestration products included in the design of a building. (See "fenestration product")

FIELD-FABRICATED FENESTRATION PRODUCT OR EXTERIOR DOOR is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits and curtainwalls).

FIREPLACE is a hearth and firechamber or similar prepared place in which a solid fuel fire may be burned, as defined in UBC Section 3102.2 and as further clarified in UBC Section 3102.7; these include but are not limited to factory-built fireplaces, masonry fireplaces, and masonry heaters.

FLOOR/SOFFIT TYPE is a floor/soffit assembly having a specific heat capacity, framing type, and U value/U factor.

FRAMED PARTITION or ASSEMBLY is a partition or assembly constructed using separate structural members spaced not more than 32 inches on center.

FRAMING PERCENTAGE is the fraction of the surface of a partition that is framed expressed in percentage.

GAS HEATING SYSTEM is a natural gas or liquefied petroleum gas heating system.

GAS LOG is a self contained, free standing, open flame, gas burning appliance consisting of a metal frame or base supporting simulated logs, and designed for installation only in a vented fireplace.

GENERAL LIGHTING is lighting designed to provide a substantially uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect. When designed for lower than task illuminance used in conjunction with other specific task lighting systems, it is also called "ambient" lighting.

GLAZING (See FENESTRATION PRODUCT).

GOVERNMENTAL AGENCY is any public agency or subdivision thereof, including, but not limited to, any agency of the state, a county, a city, a district, an association of governments, or a joint power agency.

GROSS EXTERIOR ROOF AREA is the sum of the skylight area and the exterior roof/ceiling area.

GROSS EXTERIOR WALL AREA is the sum of the window area, door area, and exterior wall area.

GROSS SALES FLOOR AREA is the total area (in square feet) of retail store floor space that is (1) used for the display and sale of merchandise; or (2) associated with that function, including, but not limited to, sales transactions areas, fitting rooms, and circulation areas and entry areas within the space used for display and sale.

GROSS SALES WALL AREA is the area (in square feet) of the inside of exterior walls and permanent full height interior partitions within the gross sales floor area of a retail store that is used for the presentation of merchandise for sale, less the area of openings, doors, windows, baseboards, wainscots, mechanical or structural elements, and other obstructions preventing the use of the area for the presentation of merchandise.

HABITABLE STORY is a story that contains space in which humans may work or live in reasonable comfort, and that has at least 50 percent of its volume above grade.

HEAT CAPACITY (HC) of an assembly is the amount of heat necessary to raise the temperature of all the components of a unit area in the assembly one degree F. It is calculated as the sum of the average thickness times the density times the specific heat for each component, and is expressed in Btu per square foot per degree F.

HEAT PUMP is a device that is capable of heating by refrigeration, and that may include a capability for cooling.

HEATING EQUIPMENT is equipment used to provide mechanical heating for a room or rooms in a building.

HEATING SEASONAL PERFORMANCE FACTOR (HSPF) is the total heating output of a heat pump (in British thermal units) during its normal use period for heating divided by the total electrical energy input (in watt hours) during the same period, as determined using the applicable test method in the Appliance Efficiency Regulations.

HI is the Hydronics Institute.

HIGH BAY is a space with luminaires 25 feet or more above the floor.

HIGH-RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel, of occupancy group R-1 with four or more habitable stories.

HORIZONTAL GLAZING (See SKYLIGHT).

HOTEL/MOTEL is a building or buildings incorporating six or more guest rooms or a lobby serving six or more guest rooms, where the guest rooms are intended or designed to be used, or which are used, rented, or hired out to be occupied, or which are occupied for sleeping purposes by guests, and all conditioned spaces within the same building envelope. Hotel/motel also includes all conditioned spaces which are (1) on the same property as the hotel/motel, (2) served by the same central HVAC system as the hotel/motel, and (3) integrally related to the functioning of the hotel/motel as such, including, but not limited to, exhibition facilities, meeting and conference facilities, food service facilities, lobbies, and laundries.

HVAC SYSTEM (see SPACE CONDITIONING SYSTEM).

ILLUMINATED FACE is a side of an exit sign that has the word "EXIT" on it.

INDIRECTLY CONDITIONED SPACE is enclosed space including, but not limited to, unconditioned volume in atria, that (1) is not directly conditioned space; and (2) either (a) has an area weighted heat transfer coefficient to directly conditioned space exceeding that to the outdoors or to unconditioned space, or (b) is a space through which air from directly conditioned spaces is transferred at a rate exceeding 3 air changes per hour.

INFILTRATION is uncontrolled inward air leakage from outside a building, or unconditioned space, including leakage through cracks and interstices, around windows and doors, and through any other exterior or demising partition or pipe or duct penetration.

INTEGRATED PART LOAD VALUE (IPLV) is a single number figure of merit based on part load EER or COP expressing part load efficiency for air conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment as determined using the applicable test method in the Appliance Efficiency Regulations or Section 112.

ISOLATION DEVICE is a device that prevents the conditioning of a zone or group of zones in a building while other zones of the building are being conditioned.

LOW BAY is a space with luminaires less than 25 feet above the floor.

LOW RISE RESIDENTIAL BUILDING is a building, other than a hotel/motel, that is of occupancy group R-1 and is three stories or less, or that is of occupancy group R-3.

LPG is Liquefied Petroleum Gas.

LUMEN MAINTENANCE DEVICE is a device capable of automatically adjusting the light output of a lighting system throughout a continuous range to provide a preset level of illumination.

LUMINAIRE is a complete lighting unit consisting of a lamp and the parts designed to distribute the light, to position and protect the lamp, and to connect the lamp to the power supply, commonly referred to as "lighting fixtures" or "instruments."

MANUAL is capable of being operated by personal intervention.

MANUFACTURED DEVICE is any heating, cooling, ventilation, lighting, water heating, refrigeration, cooking, plumbing fitting, insulation, door, fenestration product, or any other appliance, device, equipment, or system subject to Sections 110 through 119 of Title 24, Part 6.

MANUFACTURED FENESTRATION PRODUCT is a fenestration product typically assembled before delivery to a job site. "Knocked down" or partially assembled products sold as a fenestration product must be considered a manufactured fenestration product and meet the rating and labeling requirements for manufactured fenestration products.

MECHANICAL COOLING is lowering the temperature within a space using refrigerant compressors or absorbers, desiccant dehumidifiers, or other systems that require energy from depletable sources to directly condition the space. In nonresidential, high-rise residential, and hotel/motel buildings cooling of a space by direct or indirect evaporation of water alone is not considered mechanical cooling.

MECHANICAL HEATING is raising the temperature within a space using electric resistance heaters, fossil fuel burners, heat pumps, or other systems that require energy from depletable sources to directly condition the space.

MODELING ASSUMPTIONS are the conditions (such as weather conditions, thermostat settings and schedules, internal gain schedules, etc.) that are used for calculating a building's annual energy consumption and that are in the Alternative Calculation Methods Manuals.

MOVABLE SHADING DEVICE (See OPERABLE SHADING DEVICE).

MULTI SCENE DIMMING SYSTEM is a lighting control device that has the capability of setting light levels throughout a continuous range, and that has pre-established settings within the range.

NEWLY CONDITIONED SPACE is any space being converted from unconditioned to directly conditioned or indirectly conditioned space. Newly conditioned space must comply with the requirements for an addition. See Section 149 for nonresidential occupancies and Section 152 for residential occupancies.

NONRESIDENTIAL BUILDING is any building which is of occupancy group A, B, E, or H.

NOTE: Requirements for high rise residential buildings and hotels/motels are included in the nonresidential sections of Title 24, Part 6.

NONRESIDENTIAL MANUAL is the manual developed by the Commission, under Section 25402.1(e) of the Public Resources Code, to aid designers, builders and contractors in meeting the energy efficiency requirements for nonresidential, high rise residential, and hotel/motel buildings.

NORTH-FACING is oriented to within 45 degrees of true north, including 45°00'00" east of north (NE), but excluding 45°00'00" west of north (NW).

OCCUPANCY SENSOR, LIGHTING is a device that automatically turns lights off soon after an area is vacated.

OCCUPANCY TYPE is one of the following:

AUDITORIUM: The part of a public building where an audience sits in fixed seating, or a room, area, or building with fixed seats used for public meetings or gatherings not specifically for the viewing of dramatic performances.

AUTO REPAIR: The portion of a building used to repair automotive equipment and/or vehicles, exchange parts, and may include work using an open flame or welding equipment.

BANK/FINANCIAL INSTITUTION: An area in a public establishment for conducting financial transactions including the custody, loan, exchange, or issue of money, for the extension of credit, and for facilitating the transmission of funds.

CLASSROOM, LECTURE, OR TRAINING: A room or area where an audience or class receives instruction.

COMMERCIAL AND INDUSTRIAL STORAGE: A room, area, or building used for storing items.

CONVENTION, CONFERENCE, MULTIPURPOSE AND MEETING CENTERS: An assembly room, area, or building that is used for meetings, conventions and multiple purposes including, but not limited to, dramatic performances, and that has neither fixed seating nor fixed staging.

CORRIDOR: A passageway or route into which compartments or rooms open.

DINING: A room or rooms in a restaurant or hotel/motel (other than guest rooms) where meals that are served to the customers will be consumed.

ELECTRICAL/MECHANICAL ROOM: A room in which the building's electrical switchbox or control panels, and/or HVAC controls or equipment is located.

EXERCISE CENTER/GYMNASIUM: A room or building equipped for gymnastics, exercise equipment, or indoor athletic activities.

EXHIBIT: A room or area that is used for exhibitions that has neither fixed seating nor fixed staging.

GENERAL COMMERCIAL AND INDUSTRIAL WORK: A room, area, or building in which an art, craft, assembly or manufacturing operation is performed.

HIGH BAY: Luminaires 25 feet or more above the floor.

LOW BAY: Luminaires less than 25 feet above the floor.

GROCERY STORE: A room, area, or building that has as its primary purpose the sale of foodstuffs requiring additional preparation prior to consumption.

HOTEL FUNCTION AREA: A hotel room or area such as a hotel ballroom, meeting room, exhibit hall, or conference room, together with prefuction areas and other spaces ancillary to its function.

HOTEL LOBBY: The contiguous spaces in a hotel/motel between the main entrance and the front desk, including waiting and seating areas, and other spaces encompassing the activities normal to a hotel lobby function.

KITCHEN/FOOD PREPARATION: A room or area with cooking facilities and/or an area where food is prepared.

LAUNDRY: A place where laundering activities occur.

LIBRARY: A repository for literary materials, such as books, periodicals, newspapers, pamphlets and prints, kept for reading or reference.

LOCKER/DRESSING ROOM: A room or area for changing clothing, sometimes equipped with lockers.

LOUNGE/RECREATION: A room used for leisure activities which may be associated with a restaurant or bar.

MAIN ENTRY LOBBY/RECEPTION/WAITING: The lobby of a building that is directly located by the main entrance of the building and includes the reception area, sitting areas, and public areas.

MALLS, ARCADES AND ATRIA: A public passageway or concourse that provides access to rows of stores or shops.

MEDICAL AND CLINICAL CARE: A room, area, or building that does not provide overnight patient care and that is used to promote the condition of being sound in body or mind through medical, dental, or psychological examination and treatment, including, but not limited to, laboratories and treatment facilities.

MUSEUM: A space in which works of artistic, historical, or scientific value are cared for and exhibited.

OFFICE: A room, area, or building of UBC group B occupancy other than restaurants.

PRECISION COMMERCIAL OR INDUSTRIAL WORK: A room, area, or building in which an art, craft, assembly or manufacturing operation is performed involving visual tasks of small size or fine detail such as electronic assembly, fine woodworking, metal lathe operation, fine hand painting and finishing, egg processing operations, or tasks of similar visual difficulty.

RECEPTION/WAITING AREA: An area where customers or clients are greeted prior to conducting business.

RELIGIOUS WORSHIP: A room, area, or building for worship.

RESTAURANT: A room, area, or building that is a food establishment as defined in Section 27520 of the Health and Safety Code.

RESTROOM: A room or suite of rooms providing personal facilities such as toilets and washbasins.

RETAIL AND SALES: A room, area, or building in which the primary activity is the sale of merchandise.

SCHOOL: A building or group of buildings that is predominately classrooms and that is used by an organization that provides instruction to students.

STAIRS, ACTIVE/INACTIVE: A series of steps providing passage from one level of a building to another.

SUPPORT AREAS: A room or area used as a passageway, utility room, storage space, or other type of space associated with or secondary to the function of an occupancy that is listed in these regulations.

THEATER, MOTION PICTURE: An assembly room, hall, or building with tiers of rising seats or steps for the showing of motion pictures.

THEATER, PERFORMANCE: An assembly room, hall, or building with tiers of rising seats or steps for the viewing of dramatic performances, lectures, musical events and similar live performances.

VOCATIONAL ROOM: A room used to provide training in a special skill to be pursued as a trade.

WHOLESALE SHOWROOM: A room where samples of merchandise are displayed.

OPERABLE SHADING DEVICE is a device at the interior or exterior of a building or integral with a fenestration product, which is capable of being operated, either manually or automatically, to adjust the amount of solar radiation admitted to the interior of the building.

OPTIMAL OVERHANG is an overhang that completely shades the glazing at solar noon on August 21 and substantially exposes the glass at solar noon on December 21.

ORNAMENTAL CHANDELIERS are ceiling mounted, close to ceiling, or suspended decorative luminaires that use glass, crystal, ornamental metals, or other decorative material and that typically are used in hotel/motels, restaurants, or churches as a significant element in the interior architecture.

OUTDOOR AIR (Outside air) is air taken from outdoors and not previously circulated in the building.

OVERALL HEAT GAIN is the value obtained in Section 143(b)2 for determining compliance with the component envelope approach.

OVERALL HEAT LOSS is the value obtained in Section 143(b)1 for determining compliance with the component envelope approach.

PLENUM is an air compartment or chamber, including uninhabited crawl space, areas above a ceiling or below a floor, including air spaces below raised floors of computer/data processing centers, or attic spaces, to which one or more ducts are connected and which forms part of either the supply air, return air or exhaust air system, other than the occupied space being conditioned.

POOR QUALITY LIGHTING TASKS are visual tasks that require illuminance category "E" or greater, because of the choice of a writing or printing method that produces characters that are of small size or lower contrast than good quality alternatives that are regularly used in offices.

PRIVATE OFFICE or WORK AREA is an office bounded by 30 inch or higher partitions and is no more than 200 square feet.

PROCESS is an activity or treatment that is not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

PROCESS LOAD is a load resulting from a process.

PUBLIC AREAS are spaces generally open to the public at large, customers, congregation members, or similar spaces, where occupants need to be prevented from controlling lights for safety, security, or business reasons.

PUBLIC FACILITY RESTROOM is a restroom designed for use by the public.

RAISED FLOOR is a floor (partition) over a crawl space, or an unconditioned space, or ambient air.

RADIANT BARRIER is any reflective material that has an emittance of 0.05 or less, tested in accordance with ASTM C-1371-98, and that is certified to the California Department of Consumer Affairs.

READILY ACCESSIBLE is capable of being reached quickly for operation, repair, or inspection, without requiring climbing or removing obstacles, or resorting to access equipment.

RECOOL is the cooling of air that has been previously heated by space conditioning equipment or systems serving the same building.

RECOVERED ENERGY is energy used in a building that (1) is mechanically recovered from space conditioning, service water heating, lighting, or process equipment after the energy has performed its original function; (2) provides space conditioning, service water heating, or lighting; and (3) would otherwise be wasted.

REDUCED FLICKER OPERATION is the operation of a light, in which the light has a visual flicker less than 30% for frequency and modulation.

REFERENCE COMPUTER PROGRAM is the DOE 2.1E program, version 86. Note that the *reference computer program* is only part of the *reference method* which is the official set of procedures and additional calculational algorithms, that uses the the official rules and assumptions along with the *reference computer program* to manipulate required inputs to:

- 1) describe the salient, energy consuming features of a proposed building design; and to
- 2) create and describe relevant energy consuming aspects of a standard building design that meets the prescriptive building energy efficiency standards; and to
- 3) simulate both proposed and standard building designs and determine if the energy consumption of the proposed building is less than the standard building; and to
- 4) print a specific set of required compliance forms if and only if the calculated energy budget for the standard building design is greater than the proposed building design.

In the absence of other information to the contrary, the *reference method* is described in the most detail in the *reference method* input files in the Supplement to this manual.

REHEAT is the heating of air that has been previously cooled by cooling equipment or systems or an economizer.

RELATIVE SOLAR HEAT GAIN is the ratio of solar heat gain through a fenestration product (corrected for external shading) to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

REPAIR is the reconstruction or renewal of any part of an existing building for the purpose of its maintenance. Note: Repairs to low-rise residential buildings are not within the scope of these standards.

RESIDENTIAL BUILDING (See HIGH RISE RESIDENTIAL BUILDING and LOW RISE RESIDENTIAL BUILDING).

RESIDENTIAL MANUAL is the manual developed by the Commission, under Section 25402.1(e) of the Public Resources Code, to aid designers, builders, and contractors in meeting energy efficiency standards for low rise residential buildings.

ROOF is the exterior surface on the top of a building, which has a slope less than 60 degrees from horizontal.

ROOF/CEILING TYPE is a roof/ceiling assembly having a specific framing type and U factor/U value.

ROOM CAVITY RATIO (RCR) is:

$$\frac{5 \times H \times (L + W)}{L \times W}$$

or

$$\frac{(b) \text{ for irregular shaped rooms}}{A} = \frac{2.5 \times H \times P}{A}$$

Where:

L = Length of room

W = Width of room

H = Vertical distance from the work plane to the center line of the lighting fixture

P = Perimeter of room

A = Area of room

RUNOUT is piping that is no more than 12 feet long and that is connected to a fixture or an individual terminal unit.

SCONCE is a wall mounted decorative light fixture.

SEASONAL ENERGY EFFICIENCY RATIO (SEER) means the total cooling output of a central air conditioner in British thermal units during its normal usage period for cooling divided by the total electrical energy input in watt hours during the same period, as determined using the applicable test method in the Appliance Efficiency Regulations.

SEMI-CONDITIONED SPACE is an enclosed nonresidential space that is provided with wood heating, cooling by direct or indirect evaporation of water, mechanical heating that has a capacity of 10 Btu/(hr ft²) or less, mechanical cooling that has a capacity of 5 Btu/(hr ft²) or less, or is maintained for a process environment as set forth in the definition of DIRECTLY CONDITIONED SPACE.

SERVICE WATER HEATING is heating of water for sanitary purposes for human occupancy, other than for comfort heating.

SHADING is the protection from heat gains because of direct solar radiation by permanently attached exterior devices or building elements, interior shading devices, glazing material, or adherent materials. Permanently attached means (a) attached with fasteners that require additional tools to remove (as opposed to clips, hooks, latches, snaps, or ties), or (b) required by the UBC for emergency egress to be removable from the interior without the use of tools.

SHADING COEFFICIENT (SC) is the ratio of the solar heat gain through a fenestration product to the solar heat gain through an unshaded 1/8 inch thick clear double strength glass under the same set of conditions. For nonresidential, high-rise residential, and hotel/motel buildings, this shall exclude the effects of mullions, frames, sashes, and interior and exterior shading devices.

SITE-ASSEMBLED FENESTRATION includes both field-fabricated fenestration and site-built fenestration.

SITE-BUILT FENESTRATION PRODUCTS are fenestration products designed to be field glazed or field assembled units comprised of specified framing and glazing components. Site-built fenestration is eligible for certification under NFRC 100-SB, and may include both vertical glazing and horizontal glazing.

SITE SOLAR ENERGY is natural daylighting, or thermal, chemical, or electrical energy derived from direct conversion of incident solar radiation at the building site.

SKYLIGHT is glazing having a slope less than 60 degrees from the horizontal with conditioned space below, except for purposes of complying with Section 151(f), where a skylight is glazing having a slope not exceeding 4.76 degrees (1:12) from the horizontal.

SKYLIGHT AREA is the area of the surface of a skylight, plus the area of the frame, sash, and mullions.

SKYLIGHT TYPE is a type of skylight assembly having a specific solar heat gain coefficient, whether translucent or transparent, and U value U factor, whether glass mounted on a curb, glass not mounted on a curb or plastic (assumed to be mounted on a curb).

SMACNA is the Sheet Metal and Air conditioning Contractors National Association.

SOLAR HEAT GAIN COEFFICIENT (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

SOURCE ENERGY is the energy that is used at a site and consumed in producing and in delivering energy to a site, including, but not limited to, power generation, transmission, and distribution losses, and that is used to perform a specific function, such as space conditioning, lighting or water heating. Table 1-B contains the conversion factors for converting site to source energy.

SOUTH FACING is oriented to within 45 degrees of true south including 45°00'00" west of south (SW), but excluding 45°00'00" east of south (SE).

SPA is a vessel that contains heated water, in which humans can immerse themselves, is not a pool, and is not a bathtub.

SPACE CONDITIONING SYSTEM is a system that provides either collectively or individually heating, ventilating, or cooling within or associated with conditioned spaces in a building.

SPECIFIC HEAT is the quantity of heat that must be supplied to a unit mass of the material to increase its temperature by one degree as documented in an ASHRAE handbook, a comparably reliable reference or manufacturer's literature.

SYSTEM is a combination of equipment, controls, accessories, interconnecting means, or terminal elements, by which energy is transformed to perform a specific function, such as space conditioning, service water heating, or lighting.

TASK ORIENTED LIGHTING is lighting that is designed specifically to illuminate a task location, and that is generally confined to the task location.

THERMAL CONDUCTIVITY is the quantity of heat that will flow through a unit area of the material per hour when the temperature difference through the material is one degree as documented in an ASHRAE handbook, a comparably reliable reference or manufacturer's literature.

THERMAL MASS is solid or liquid material used to store heat for later heating use or for reducing cooling requirements.

THERMAL RESISTANCE (R) is the resistance of a material or building component to the passage of heat in hr·ft²·°F/Btu.

THERMOSTATIC EXPANSION VALVE (TXV) is a refrigerant metering valve, installed in an air conditioner or heat pump, which controls the flow of liquid refrigerant entering the evaporator in response to the superheat of the gas leaving it.

THROW DISTANCE is the distance between the luminaire and the center of the plane lit by the luminaire on a display.

TUNING is a lighting control device that allows authorized personnel only to select a single light level within a continuous range.

UBC is the 1994 edition of the state adopted Uniform Building Code, Title 24.

UL is the Underwriters Laboratory.

UMC is the 1997 edition of the state adopted Uniform Mechanical Code.

UNCONDITIONED SPACE is enclosed space within a building that is not directly conditioned, indirectly conditioned, or semi-conditioned space.

UNIT INTERIOR MASS CAPACITY (UIMC) is the amount of effective heat capacity per unit of thermal mass, taking into account the type of mass material, thickness, specific heat, density and surface area.

U-VALUE U-FACTOR is the overall coefficient of thermal transmittance of a construction assembly, in Btu/h·ft²·°F, including air film resistance at both surfaces.

VAPOR BARRIER is a material that has a permeance of one perm or less and that provides resistance to the transmission of water vapor.

VARIABLE AIR VOLUME (VAV) SYSTEM is a space conditioning system that maintains comfort levels by varying the volume of conditioned air to the zones served.

VERTICAL GLAZING (See "window")

VERY VALUABLE MERCHANDISE is rare or precious objects, including, but not limited to, jewelry, coins, small art objects, crystal, china, ceramics, or silver, the selling of which involves customer inspection of very fine detail from outside of a locked case.

VISIBLE LIGHT TRANSMITTANCE (VLT) is the ratio (expressed as a decimal) of visible light that is transmitted through a glazing material to the light that strikes the material.

WALL TYPE is a wall assembly having a specific heat capacity, framing type, and U valueU factor.

WELL INDEX is the ratio of the amount of visible light leaving a skylight well to the amount of visible light entering the skylight well and is calculated as follows:

— (a) for rectangular wells:



— or

— (b) for irregular shaped wells:



Where the length, width, perimeter, and area are measured at the bottom of the well, and R is the weighted average reflectance of the walls of the well.

WEST FACING is oriented to within 45 degrees of true west, including 45°00'00" north of due west (NW), but excluding 45°00'00" south of west (SW).

WINDOW is glazing that is not a skylight.

WINDOW AREA is the area of the surface of a window, plus the area of the frame, sash, and mullions.

WINDOW TYPE is a window assembly having a specific solar heat gain coefficient, relative solar heat gain, and U valueU factor.

WINNDOW WALL RATIO is the ratio of the window area to the gross exterior wall area.

WOOD HEATER is an enclosed wood burning appliance used for space heating and/or domestic water heating, and which meets the definition in Federal Register, Volume 52, Number 32, February 18, 1987.

WOOD STOVE (See WOOD HEATER).

ZONE, LIGHTING is a space or group of spaces within a building that has sufficiently similar requirements so that lighting can be automatically controlled in unison throughout the zone by an illumination-controlling device or devices, and does not exceed one floor.

ZONE, SPACE CONDITIONING is a space or group of spaces within a building with sufficiently similar comfort conditioning requirements so that comfort conditions, as specified in 144(b)3 or 150(h), as applicable, can be maintained throughout the zone by a single controlling device.

ACM NF-2005**Appendix NF - Technical Databases for Test Runs**

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Table NF-14 – ACM ELECTRICAL CHILLER LIBRARY

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Table NF-17 – ACM BOILER LIBRARY

Table NF-18 – ACM VAV BOX SELECTED

Table NF-19 – ACM PACKAGE UNITS SELECTED

Table NF-20 – ACM WATER LOOP HEAT PUMP SELECTED

Table NF-21 – ACM EVAPORATIVE COOLING EQUIPMENT SELECTED

Table NF-22 – FAN COIL UNITS SELECTED

Table NF-23 – ACM HEAT PUMP EQUIPMENT SELECTED

Table NF-24 – ACM SYSTEM EQUIPMENT SELECTED

Table NF-25 – ACM CENTRAL COOLING EQUIPMENT SELECTED

Table NF-26 – ACM BOILER SELECTION

Table NF-1 – ACM MATERIAL LIBRARY

NAME	THICKNESS (feet)	CONDUCT.	DENSITY	SP-HEAT	R-VALUE
2X4	0.2917	0.0842	35.00	0.39	
2X6	0.4583	0.0842	35.00	0.39	
AIRWALL-MAT					1.00
CARPET2					2.00
CEL-2.5	0.2083	0.0333	5.00	0.32	
EARTH	1.0000	0.5000	85.00	0.20	
HC1.42U057-MAT	1.0000	0.0604	7.11	0.20	
HC1.42U078-MAT	1.0000	0.0839	7.11	0.20	
HC19R2.375	0.9500	0.4000	100.00	0.20	
HC9.67R1.209	0.4835	0.4000	100.00	0.20	
ISO-3.0	0.2500	0.0142	1.50	0.38	
PERIM	1.3330	0.9300	82.00	0.22	
R1.60					1.60
R1.95					1.95
R10-RIGID-INS	0.1667	0.0167	14.00	0.17	
R11-INS	0.2917	0.0265	0.60	0.20	
R13-INS	0.2917	0.0224	0.60	0.20	
R19-INS	0.5035	0.0265	0.60	0.20	
R30-INS	0.7500	0.0265	0.60	0.20	
R4-RIGID-INS	0.0833	0.0218	14.00	0.17	
R4.76					4.76
R5.93					5.93
R7-RIGID-INS	0.0833	0.0119	14.00	0.17	
RHC6U057-MAT	1.0000	0.0597	30.00	0.20	
RHC6U078-MAT	1.0000	0.0834	30.00	0.20	
SC2A	0.0729	0.4288	166.00	0.20	
SPANDREL-R10-MAT	1.0000	0.0100	25.00	0.20	
SPANDREL-R15-MAT	1.0000	0.0667	30.00	0.20	
W1A-R11	0.2950	0.0952	5.50	0.13	
W1B-R13	0.2950	0.0894	5.50	0.13	
W1D-R17	0.2950	0.0720	5.50	0.13	
W2A-R11	0.2917	0.0265	5.50	0.13	
W2B-R13	0.2917	0.0224	5.50	0.13	
W2C-R18	0.4583	0.0257	5.50	0.13	
W2D-R21	0.4583	0.0218	5.50	0.13	
W3A-MAT	0.3333	0.2259	168.00	0.20	
W3B-MAT	0.3333	0.1595	168.00	0.20	
W4A-MAT	0.5000	0.8333	162.00	0.20	
W4B-MAT	0.5000	0.7257	162.00	0.20	
W4C-MAT	0.5000	0.3030	162.00	0.20	
W4D-MAT	0.5000	0.2594	162.00	0.20	
WD4G	0.2917	0.0667	32.00	0.33	
WD6G	0.4583	0.0667	32.00	0.33	
WHC2.4U084-MAT	1.0000	0.0905	42.00	0.20	

NAME	THICKNESS (feet)	CONDUCT.	DENSITY	SP-HEAT	R-VALUE
WHC2.4U092-MAT	1.0000	0.0994	12.00	0.20	
WHC5U084-MAT	1.0000	0.0905	25.00	0.20	
WHC5U092-MAT	1.0000	0.0998	25.00	0.20	

Table NF-2 – ACM LAYERS LIBRARY

Name	Mat[1]	Mat[2]	Mat[3]	Mat[4]	Mat[5]	I-F-R
AIRWALL-LAY	AIRWALL-MAT					0.68
CONC-SPANDEL-LAY	CC22	W1B-R13	GP02			0.68
DEMISING-LAY	GP01	W1A-R11	GP01			0.68
DOORC-LAY	AS01	WD11	AS01			0.68
FHC19U097-LAY	R4.76	HC19R2.375	GP04			0.92
FHC19U158-LAY	R1.60	HC19R2.375	GP04			0.92
FHC9.67U097-LAY	R5.93	HC9.67R1.209	GP04			0.92
FHC9.67U158-LAY	R1.95	HC9.67R1.209	GP04			0.92
FLR-CONC-CAV-LAY	CEL-2.5	CC03	CP01			0.92
FLR-CONC-RAK-LAY	CEL-2.5	CC05	CP01			0.92
FX02X6-FRM-LAY	2X6	PW04	CARPET2			0.92
FX02X6-INS-LAY	PW04	CARPET2				0.92
FX112X6-FRM-LAY	2X6	PW04	CARPET2			0.92
FX112X6-INS-LAY	W2A-R11	PW04	CARPET2			0.92
FX132X6-FRM-LAY	2X6	PW04	CARPET2			0.92
FX132X6-INS-LAY	W2B-R13	PW04	CARPET2			0.92
INTWALL-LAY	GP03	GP03	GP03			0.68
RF-INTERIOR-LAY	CC04	CP01				0.61
RF-ISO3.0-LAY	BR01	ISO-3.0	PW04			0.61
RF1B-NR-LAY	BR04	PW04	AL23	W2A-R11	GP04	0.61
RF1B-NRF-LAY	BR04	PW04	2X6	GP04		0.61
RF1C-NR-LAY	BR04	PW04	W2C-R18	GP04		0.61
RF1C-NRF-LAY	BR04	PW04	WD6C	GP04		0.61
RF1D-NR-LAY	BR04	R7-RIGID-INS	PW04	W2C-R18	GP04	0.61
RF1D-NRF-LAY	BR04	R7-RIGID-INS	PW04	2X6	GP04	0.61
RHC142U057-LAY	HC142U057-MAT					0.61
RHC142U078-LAY	HC142U078-MAT					0.61
RHC6U057-LAY	RHC6U057-MAT					0.61
RHC6U078-LAY	RHC6U078-MAT					0.61
ROOFI-F-LAY	CC32	PW05	WD05	WD05		0.61
ROOFI-LAY	CC32	PW05				0.61
SLAB-LAY	EARTH	CC14				0.92
SLABC-LAY	EARTH	CC14	CP01			0.92
SLABP-LAY	EARTH	CC14	CP01			0.92
SPANDREL-R10-LAY	SPANDREL-R10-MAT					0.68
SPANDREL-R15-LAY	SPANDREL-R15-MAT					0.61
W1A-LAY	SC2A	PW03	W1A-R11	GP02		0.68
W1B-LAY	SC2A	PW03	W1B-R13	GP02		0.68
W1D-LAY	SC2A	IN33	PW03	W1D-R17	GP04	0.68
W2A-FRM-LAY	PW03	BP01	WD04	GP04		0.68
W2A-INS-LAY	PW03	BP01	W2A-R11	GP04		0.68
W2B-FRM-LAY	PW03	BP01	WD04	GP04		0.68
W2B-INS-LAY	PW03	BP01	W2B-R13	GP04		0.68
W2D-FRM-LAY	PW03	BP01	WD6C	GP04		0.68
W2D-INS-LAY	PW03	BP01	W2D-R21	GP04		0.68

Name	Mat[1]	Mat[2]	Mat[3]	Mat[4]	Mat[5]	I-F-R
W3A-LAY	W3A-MAT					0.68
W3B-LAY	W3B-MAT					0.68
W4A-LAY	W4A-MAT					0.68
W4B-LAY	W4B-MAT					0.68
W4C-LAY	W4C-MAT					0.68
W4D-LAY	W4D-MAT					0.68
WHC2.4U084-LAY	WHC2.4U084-MAT					0.68
WHC2.4U092-LAY	WHC2.4U092-MAT					0.68
WHC5U084-LAY	WHC5U084-MAT					0.68
WHC5U092-LAY	WHC5U092-MAT					0.68
WIZ-LAY	GP02	W1A-R11		GP02		0.68

Table NF-3—ACM CONSTRUCTION LIBRARY

Construction	Layers	ABS	RO
AIRWALL	AIRWALL-LAY	0.7	3
CONC-SPANDEL	CONC-SPANDEL-LAY	0.7	3
DEMISING	DEMISING-LAY	0.7	3
DOORC	DOORC-LAY	0.7	3
FHC19U097	FHC19U097-LAY	0.7	3
FHC19U158	FHC19U158-LAY	0.7	3
FHC9.67U097	FHC9.67U097-LAY	0.7	3
FHC9.67U158	FHC9.67U158-LAY	0.7	3
FLR-CONC-CAV	FLR-CONC-CAV-LAY	0.7	3
FLR-CONC-RAK	FLR-CONC-RAK-LAY	0.7	3
FX02X6-FRM	FX02X6-FRM-LAY	0.7	3
FX02X6-INS	FX02X6-INS-LAY	0.7	3
FX112X6-FRM	FX112X6-FRM-LAY	0.7	3
FX112X6-INS	FX112X6-INS-LAY	0.7	3
FX132X6-FRM	FX132X6-FRM-LAY	0.7	3
FX132X6-INS	FX132X6-INS-LAY	0.7	3
INTWALL	INTWALL-LAY	0.7	3
RF-INTERIOR	RF-INTERIOR-LAY	0.7	3
RF-ISO3.0	RF-ISO3.0-LAY	0.7	3
RF1B-NR	RF1B-NR-LAY	0.7	3
RF1B-NRF	RF1B-NRF-LAY	0.7	3
RF1C-NR	RF1C-NR-LAY	0.7	3
RF1C-NRF	RF1C-NRF-LAY	0.7	3
RF1D-NR	RF1D-NR-LAY	0.7	3
RF1D-NRF	RF1D-NRF-LAY	0.7	3
RHC1.42U057	RHC1.42U057-LAY	0.7	3
RHC1.42U078	RHC1.42U078-LAY	0.7	3
RHC6U057	RHC6U057-LAY	0.4	3
RHC6U078	RHC6U078-LAY	0.4	3
ROOFI	ROOFI-LAY	0.7	3
ROOFI-F	ROOFI-F-LAY	0.7	3
SLAB	SLAB-LAY	0.1	3
SLABC	SLABC-LAY	0.1	3
SLABP	SLABP-LAY	0.1	3
SPANDREL-R10	SPANDREL-R10-LAY	0.7	3
SPANDREL-R15	SPANDREL-R15-LAY	0.4	3
W1A	W1A-LAY	0.7	3
W1B	W1B-LAY	0.7	3
W1D	W1D-LAY	0.7	3
W2A-FRM	W2A-FRM-LAY	0.7	3
W2A-INS	W2A-INS-LAY	0.7	3
W2B-FRM	W2B-FRM-LAY	0.7	3
W2B-INS	W2B-INS-LAY	0.7	3
W2D-FRM	W2D-FRM-LAY	0.7	3
W2D-INS	W2D-INS-LAY	0.7	3

Construction	Layers	ABS	RO
W3A	W3A-LAY	0.7	3
W3B	W3B-LAY	0.7	3
W4A	W4A-LAY	0.7	3
W4B	W4B-LAY	0.7	3
W4C	W4C-LAY	0.7	3
W4D	W4D-LAY	0.7	3
WHC2.4U084	WHC2.4U084 LAY	0.7	3
WHC2.4U092	WHC2.4U092 LAY	0.7	3
WHC5U084	WHC5U084	0.7	3
WHC5U092	WHC5U092 LAY	0.7	3
WIZ	WIZ-LAY	0.7	3

Table NF-4 – ACM VAV BOX LIBRARY

MODEL	CFM	MIN RATIO	REHEAT CAP
VAV1200A	1200	0.35	21000
VAV1200H	1200	0.30	18000
VAV1200L	1200	0.40	24000
VAV1500A	1500	0.35	26250
VAV1500H	1500	0.30	22500
VAV1500L	1500	0.40	30000
VAV2000A	2000	0.35	35000
VAV2000H	2000	0.30	30000
VAV2000L	2000	0.40	40000
VAV2500A	2500	0.35	43750
VAV2500H	2500	0.30	37500
VAV2500L	2500	0.40	50000
VAV3000A	3000	0.35	52500
VAV3000H	3000	0.30	45000
VAV3000L	3000	0.40	60000
VAV300A	300	0.35	5250
VAV300H	300	0.30	4500
VAV300L	300	0.40	6000
VAV3500A	3500	0.35	61250
VAV3500H	3500	0.30	52500
VAV3500L	3500	0.40	70000
VAV4000A	4000	0.35	70000
VAV4000H	4000	0.30	60000
VAV4000L	4000	0.40	80000
VAV4500A	4500	0.35	78750
VAV4500H	4500	0.30	67500
VAV4500L	4500	0.40	90000
VAV450A	450	0.35	7875
VAV450H	450	0.30	6750
VAV450L	450	0.40	9000
VAV5000A	5000	0.35	87500
VAV5000H	5000	0.30	75000
VAV5000L	5000	0.40	100000
VAV600A	600	0.35	10500
VAV600H	600	0.30	9000
VAV600L	600	0.40	12000
VAV900A	900	0.35	15750
VAV900H	900	0.30	13500
VAV900L	900	0.40	18000

Table NF-5 – ACM PIU EQUIPMENT LIBRARY

Model	TYP	Cfm	M-C-R	F-C-R	FPI	ReheatCap
PIU300AP	P	300	0.3	0.60	0.33	8100
PIU300AS	S	300	0.3	1.00	0.33	8100
PIU300HP	P	300	0.3	0.90	0.28	12000
PIU300HS	S	300	0.3	1.00	0.28	12000
PIU300LP	P	300	0.3	0.40	0.35	5400
PIU300LS	S	300	0.3	1.00	0.35	5400
PIU450AP	P	450	0.3	0.60	0.33	12000
PIU450AS	S	450	0.3	1.00	0.33	12000
PIU450HP	P	450	0.3	0.90	0.28	18200
PIU450HS	S	450	0.3	1.00	0.28	18200
PIU450LP	P	450	0.3	0.40	0.35	8100
PIU450LS	S	450	0.3	1.00	0.35	8100
PIU600AP	P	600	0.3	0.60	0.33	16200
PIU600AS	S	600	0.3	1.00	0.33	16200
PIU600HP	P	600	0.3	0.90	0.28	24300
PIU600HS	S	600	0.3	1.00	0.28	24300
PIU600LP	P	600	0.3	0.40	0.35	10800
PIU600LS	S	600	0.3	1.00	0.35	10800
PIU750AP	P	750	0.3	0.60	0.33	20250
PIU750AS	S	750	0.3	1.00	0.33	20250
PIU750HP	P	750	0.3	0.90	0.28	30400
PIU750HS	S	750	0.3	1.00	0.28	20250
PIU750LP	P	750	0.3	0.40	0.35	13500
PIU750LS	S	750	0.3	1.00	0.35	13500
PIU900AP	P	900	0.3	0.60	0.33	24300
PIU900AS	S	900	0.3	1.00	0.33	24300
PIU900HP	P	900	0.3	0.90	0.28	36500
PIU900HS	S	900	0.3	1.00	0.28	36500
PIU900LP	P	900	0.3	0.40	0.35	16200
PIU900LS	S	900	0.3	1.00	0.35	16200

Table NF-6—ACM SMALL PACKAGE SPLIT AIR CONDITIONER

Model	Cap95	Cap82	EER	SEER	CFM	Cd	FPIcv	FPIav	HCAP	AFUE
ACSP17A	17000	18850	9.60	9.90	500	0.15	0.50	1.00	25000	82
ACSP17H	17000	17860	9.70	10.00	500	0.20	0.35	0.75	25000	84
ACSP17L	17000	20200	9.50	9.90	500	0.10	0.90	1.30	25000	80
ACSP22A	22000	24270	9.60	9.90	600	0.15	0.50	1.00	30000	82
ACSP22H	22000	24700	10.40	12.00	600	0.20	0.35	0.75	30000	84
ACSP22L	22000	24640	9.50	9.90	600	0.10	0.90	1.30	30000	82
ACSP28A	28000	31310	9.60	9.90	800	0.15	0.50	1.00	40000	84
ACSP28H	28000	31320	10.60	12.00	800	0.20	0.35	0.75	40000	80
ACSP28L	28000	31420	9.50	9.90	800	0.10	0.90	1.30	40000	82
ACSP34A	34000	36850	9.60	9.90	1100	0.15	0.50	1.00	55000	84
ACSP34H	34000	37770	10.50	12.00	1100	0.20	0.35	0.75	55000	80
ACSP34L	34000	38370	9.50	9.90	1100	0.10	0.90	1.30	55000	82
ACSP40A	40000	43360	9.60	9.90	1200	0.15	0.50	1.00	60000	84
ACSP40H	40000	42530	10.80	12.00	1200	0.20	0.35	0.75	60000	80
ACSP40L	40000	46820	9.50	9.90	1200	0.10	0.90	1.30	60000	82
ACSP46A	46000	49770	9.60	9.90	1600	0.15	0.50	1.00	80000	84
ACSP46H	46000	51400	10.50	12.00	1600	0.20	0.35	0.75	80000	80
ACSP46L	46000	49660	9.50	9.90	1600	0.10	0.90	1.30	80000	82
ACSP52A	52000	55500	9.60	9.90	1700	0.15	0.50	1.00	85000	84
ACSP52H	52000	56280	11.10	12.50	1700	0.20	0.35	0.75	85000	80
ACSP52L	52000	56650	9.50	9.90	1700	0.10	0.90	1.30	85000	82
ACSP58A	58000	62520	9.60	9.90	1800	0.15	0.50	1.00	90000	84
ACSP58H	58000	62290	10.80	12.00	1800	0.20	0.35	0.75	90000	80
ACSP58L	58000	63360	9.50	9.90	1800	0.10	0.90	1.30	90000	82
ACSP63A	63000	67460	9.60	9.90	1900	0.15	0.50	1.00	95000	84
ACSP63H	63000	68000	10.50	12.10	1900	0.20	0.35	0.75	95000	80
ACSP63L	63000	67830	9.50	9.90	1900	0.10	0.90	1.30	95000	82

Table NF-7—ACM LARGE PACKAGE SPLIT AIR CONDITIONER LIBRARY

Model	Cap95	Cfm	BHPari	MotorEff	FPIcv	FPIvav	EER	HCap	AFUE
ACLP007A	80150	3100	0.23	0.810	0.50	1.00	9.00	93000	82
ACLP007H	79100	2800	0.21	0.875	0.35	0.75	9.20	84000	84
ACLP007L	77350	2500	0.18	0.810	0.90	1.30	8.90	75000	80
ACLP010A	114500	4500	0.41	0.850	0.50	1.00	9.00	135000	82
ACLP010H	113000	4000	0.34	0.917	0.35	0.75	9.20	120000	84
ACLP010L	110500	3500	0.30	0.850	0.90	1.30	8.90	105000	80
ACLP015A	171750	6750	0.85	0.850	0.50	1.00	8.70	202500	82
ACLP015H	169500	6000	0.67	0.917	0.35	0.75	9.00	180000	84
ACLP015L	165750	5250	0.38	0.850	0.90	1.30	8.50	157500	80
ACLP020A	229000	9000	1.60	0.850	0.50	1.00	8.70	270000	82
ACLP020H	226000	8000	1.23	0.917	0.35	0.75	9.00	240000	84
ACLP020L	221000	7000	0.92	0.850	0.90	1.30	8.50	210000	80
ACLP025A	292000	8750	1.34	0.850	0.50	1.00	8.70	262500	82
ACLP025H	281000	7000	0.79	0.917	0.35	0.75	9.00	210000	84
ACLP025L	271500	6000	0.50	0.850	0.90	1.30	8.50	180000	80
ACLP030A	352000	12000	2.13	0.850	0.50	1.00	8.70	360000	82
ACLP030H	345000	10500	1.40	0.917	0.35	0.75	9.00	315000	84
ACLP030L	337000	9000	1.09	0.850	0.90	1.30	8.50	270000	80
ACLP040A	483000	18000	4.13	0.860	0.50	0.75	8.70	540000	82
ACLP040H	476000	16000	3.02	0.910	0.35	0.75	9.00	480000	84
ACLP040L	467000	14000	2.12	0.860	0.90	1.30	8.50	420000	80
ACLP050A	589000	22500	7.60	0.860	0.50	1.00	8.70	675000	82
ACLP050H	580000	20000	5.49	0.910	0.35	0.75	9.00	600000	84
ACLP050L	569000	17500	3.75	0.860	0.90	1.30	8.50	525000	80
ACLP060A	723000	27000	7.26	0.880	0.50	1.00	8.70	810000	82
ACLP060H	712000	24000	5.41	0.930	0.35	0.75	9.00	720000	84
ACLP060L	698000	21000	3.91	0.880	0.90	1.30	8.50	630000	80
ACLP070A	811000	26000	6.60	0.880	0.50	1.00	8.50	780000	82
ACLP070H	801000	24000	5.41	0.930	0.35	0.75	8.80	720000	84
ACLP070L	815000	27000	7.26	0.880	0.90	1.30	8.20	810000	80
ACLP075A	883000	26000	6.60	0.880	0.50	1.00	8.50	780000	82
ACLP075H	873000	24000	5.41	0.930	0.35	0.75	8.80	720000	84
ACLP075L	862000	22000	3.91	0.880	0.90	1.30	8.20	660000	80
ACLP090A	1062000	42000	15.03	0.880	0.50	1.00	8.70	1260000	82
ACLP090H	1044000	37000	10.82	0.930	0.35	0.75	8.80	1110000	84
ACLP090L	1021000	32000	7.52	0.880	0.90	1.30	8.20	960000	80
ACLP105A	1229000	43000	15.99	0.890	0.50	1.00	8.50	1290000	82
ACLP105H	1213000	39000	12.39	0.941	0.35	0.75	8.80	1170000	84
ACLP105L	1193000	35000	9.40	0.880	0.90	1.30	8.20	1050000	80

Table NF-8—ACM FAN COIL EQUIPMENT LIBRARY

MODEL	COOLCAP	HEATCAP	CFM	FPI
FC008A	8400	12000	300	0.50
FC008H	8400	12000	300	0.35
FC008L	8400	12000	300	0.90
FC013A	12600	18000	450	0.50
FC013H	12600	18000	450	0.35
FC013L	12600	18000	450	0.90
FC017A	16800	24000	600	0.50
FC017H	16800	24000	600	0.35
FC017L	16800	24000	600	0.90
FC021A	21000	30000	750	0.50
FC021H	21000	30000	750	0.35
FC021L	21000	30000	750	0.90
FC028A	28000	40000	1000	0.50
FC028H	28000	40000	1000	0.35
FC028L	28000	40000	1000	0.90
FC035A	35000	50000	1250	0.50
FC035H	35000	50000	1250	0.35
FC035L	35000	50000	1250	0.90
FC042A	42000	60000	1500	0.50
FC042H	42000	60000	1500	0.35
FC042L	42000	60000	1500	0.90
FC056A	56000	80000	2000	0.50
FC056H	56000	80000	2000	0.35
FC056L	56000	80000	2000	0.90
FC070A	70000	100000	2500	0.50
FC070H	70000	100000	2500	0.35
FC070L	70000	100000	2500	0.90
FC084A	84000	120000	3000	0.50
FC084H	84000	120000	3000	0.35
FC084L	84000	120000	3000	0.90
FC098A	98000	140000	3500	0.50
FC098H	98000	140000	3500	0.35
FC098L	98000	140000	3500	0.90
FC112A	112000	160000	4000	0.50
FC112H	112000	160000	4000	0.35
FC112L	112000	160000	4000	0.90
FC126A	126000	180000	4500	0.50
FC126H	126000	180000	4500	0.35
FC126L	126000	180000	4500	0.90
FC140A	140000	200000	5000	0.50
FC140H	140000	200000	5000	0.35
FC140L	140000	200000	5000	0.90
FC168A	168000	240000	6000	0.50
FC168H	168000	240000	6000	0.35
FC168L	168000	240000	6000	0.90

MODEL	COOLCAP	HEATCAP	CFM	FPI
FC196A	196000	280000	7000	0.50
FC196H	196000	280000	7000	0.35
FC196L	196000	280000	7000	0.90
FC224A	224000	320000	8000	0.50
FC224H	224000	320000	8000	0.35
FC224L	224000	320000	8000	0.90
FC252A	252000	360000	9000	0.50
FC252H	252000	360000	9000	0.35
FC252L	252000	360000	9000	0.90
FC280A	280000	400000	10000	0.50
FC280H	280000	400000	10000	0.35
FC280L	280000	400000	10000	0.90
FC350A	350000	500000	12500	0.50
FC350H	350000	500000	12500	0.35
FC350L	350000	500000	12500	0.90
FC420A	420000	600000	15000	0.50
FC420H	420000	600000	15000	0.35
FC420L	420000	600000	15000	0.90
FC490A	490000	700000	17500	0.50
FC490H	490000	700000	17500	0.35
FC490L	490000	700000	17500	0.90
FC560A	560000	800000	20000	0.50
FC560H	560000	800000	20000	0.35
FC560L	560000	800000	20000	0.90
FC700A	700000	1000000	25000	0.50
FC700H	700000	1000000	25000	0.35
FC700L	700000	1000000	25000	0.90
FC840A	840000	1200000	30000	0.50
FC840H	840000	1200000	30000	0.35
FC840L	840000	1200000	30000	0.90

Table NF-9—ACM HEAT ONLY LIBRARY

Model	HeatCap	CFM	FPI	AFUE
HEAT045A	45000	1000	0.50	82
HEAT045H	45000	1000	0.35	84
HEAT045L	45000	1000	0.90	80
HEAT063A	63000	1500	0.50	82
HEAT063H	63000	1500	0.35	84
HEAT063L	63000	1500	0.90	80
HEAT090A	90000	2000	0.50	82
HEAT090H	90000	2000	0.35	84
HEAT090L	90000	2000	0.90	80
HEAT108A	108000	2500	0.50	82
HEAT108H	108000	2500	0.35	84
HEAT108L	108000	2500	0.90	80
HEAT135A	135000	3000	0.50	82
HEAT135H	135000	3000	0.35	84
HEAT135L	135000	3000	0.90	80
HEAT153A	153000	3500	0.50	82
HEAT153H	153000	3500	0.35	84
HEAT153L	153000	3500	0.90	80
HEAT180A	180000	4000	0.50	82
HEAT180H	180000	4000	0.35	84
HEAT180L	180000	4000	0.90	80
HEAT215A	215000	5000	0.50	82
HEAT215H	215000	5000	0.35	84
HEAT215L	215000	5000	0.90	80
HEAT323A	323000	7500	0.50	82
HEAT323H	323000	7500	0.35	84
HEAT323L	323000	7500	0.90	80
HEAT450A	450000	10000	0.50	82
HEAT450H	450000	10000	0.35	84
HEAT450L	450000	10000	0.90	80
HEAT538A	538000	12500	0.50	82
HEAT538H	538000	12500	0.35	84
HEAT538L	538000	12500	0.90	80
HEAT665A	665000	15000	0.50	82
HEAT665H	665000	15000	0.35	84
HEAT665L	665000	15000	0.90	80
HEAT900A	900000	20000	0.50	82
HEAT900H	900000	20000	0.35	84
HEAT900L	900000	20000	0.90	80

Table NF-10—ACM HEAT PUMP EQUIPMENT LIBRARY

Model	Cap 95	Cap 82	Hcap 47	Hcap 17	EER	SEER	HSPF	COP 47	COP 17	Cfm	Cd	Fpi
HPSP108A	108000		110000	58700	9.00		7.32	3.00	2.00	3300		0.50
HPSP108H	108000		109800	56300	9.20		7.32	3.00	2.00	3300		0.35
HPSP108L	108000		109800	59000	8.90		7.68	3.10	2.00	3300		0.90
HPSP126A	126000		123400	68100	9.00		7.32	3.00	2.00	4300		0.50
HPSP126H	126000		111700	59900	9.60		7.32	3.00	2.00	4300		0.35
HPSP126L	126000		128100	68900	8.90		7.68	3.10	2.00	4300		0.90
HPSP162A	162000		150600	80200	8.90		7.00	2.90	2.00	5400		0.50
HPSP162H	162000		146400	77600	9.40		7.00	2.90	2.00	5400		0.35
HPSP162L	162000		148800	77200	8.50		7.00	2.90	2.00	5400		0.90
HPSP222A	222000		224200	115400	8.60		7.32	3.00	2.00	6400		0.50
HPSP222H	222000		215900	115000	8.80		7.32	3.00	2.00	6400		0.35
HPSP222L	222000		227700	123500	8.50		7.32	3.00	2.10	6400		0.90
HPSP22A	22000	24150	21600	11900	9.60	10.50	7.32	3.00	2.00	600	0.15	0.50
HPSP22H	22000	24050	20800	10900	11.10	12.00	8.40	3.30	2.00	600	0.20	0.35
HPSP22L	22000	23390	22000	12300	9.50	10.00	7.32	3.00	2.00	600	0.10	0.90
HPSP28A	28000	30420	27500	15400	9.60	10.40	7.32	3.00	2.00	800	0.15	0.50
HPSP28H	28000	30040	25400	13900	11.20	12.00	7.32	3.00	2.00	800	0.20	0.35
HPSP28L	28000	30800	28000	15800	9.50	9.90	7.32	3.00	2.00	800	0.10	0.90
HPSP34A	34000	36980	33500	18600	9.60	10.20	7.32	3.00	2.00	1100	0.15	0.50
HPSP34H	34000	37600	31100	18000	10.70	12.00	8.40	3.30	2.20	1100	0.20	0.35
HPSP34L	34000	37790	36300	19600	9.50	9.90	7.32	3.00	2.00	1100	0.10	0.90
HPSP40A	40000	43500	39600	22000	9.60	10.00	7.32	3.00	2.00	1200	0.15	0.50
HPSP40H	40000	44140	37200	20700	10.30	12.00	8.04	3.20	2.00	1200	0.20	0.35
HPSP40L	40000	44930	41400	24000	9.50	9.90	7.32	3.00	2.00	1200	0.10	0.90
HPSP46A	46000	50000	46200	25700	9.60	10.00	7.32	3.00	2.00	1600	0.15	0.50
HPSP46H	46000	51400	46500	25600	10.40	12.00	8.04	3.20	2.10	1600	0.20	0.35
HPSP46L	46000	49830	48100	26200	9.50	9.90	7.68	3.10	2.10	1600	0.10	0.90
HPSP52A	52000	56060	51300	28000	9.60	10.00	7.32	3.00	2.00	1700	0.15	0.50
HPSP52H	52000	56820	49300	28900	9.90	12.30	8.04	3.20	2.00	1700	0.20	0.35
HPSP52L	52000	56280	51400	30000	9.50	9.90	7.32	3.00	2.00	1700	0.10	0.90
HPSP58A	58000	62530	59000	33800	9.60	10.00	7.68	3.10	2.10	1800	0.15	0.50
HPSP58H	58000	64710	58000	31500	10.10	12.00	8.40	3.30	2.20	1800	0.20	0.35
HPSP58L	58000	62140	60000	33900	9.50	9.90	7.32	3.00	2.10	1800	0.10	0.90
HPSP63A	63000	66900	60800	34300	9.60	10.00	7.32	3.00	2.00	1900	0.15	0.50
HPSP63H	63000	67260	58900	32100	9.70	10.50	7.32	3.00	2.00	1900	0.20	0.35
HPSP63L	63000	67190	59400	32600	9.50	9.90	7.32	3.00	2.00	1900	0.10	0.90
HPSP72A	72000		70600	38200	9.00		7.32	3.00	2.00	2400		0.50
HPSP72H	72000		71600	44400	9.50		7.68	3.10	2.00	2400		0.35
HPSP72L	72000		72000	35400	8.90		7.32	3.00	2.00	2400		0.90
HPSP90A	90000		90500	49300	9.00		7.32	3.00	2.00	2600		0.50
HPSP90H	90000		83400	54100	9.40		7.32	3.00	2.10	2600		0.35
HPSP90L	90000		88900	44400	8.90		7.32	3.00	2.00	2600		0.90

Table NF-11– ACM WATER LOOP EQUIPMENT LIBRARY

MODEL	COOLCAP	EER	HEATCAP	COP	CFM	FPI
WHP007A	7000	11.50	8050	4.00	230	0.50
WHP007H	7000	15.00	8050	4.50	230	0.35
WHP007L	7000	10.00	8050	3.80	230	0.85
WHP009A	9000	11.50	10350	4.00	300	0.50
WHP009H	9000	15.00	10350	4.50	300	0.35
WHP009L	9000	10.00	10350	3.80	300	0.85
WHP012A	12000	11.50	13800	4.00	400	0.50
WHP012H	12000	15.00	13800	4.50	400	0.35
WHP012L	12000	10.00	13800	3.80	400	0.85
WHP015A	15000	11.50	17250	4.00	500	0.50
WHP015H	15000	15.00	17250	4.50	500	0.35
WHP015L	15000	10.00	17250	3.80	500	0.85
WHP018A	18000	11.50	20700	4.00	600	0.50
WHP018H	18000	15.00	20700	4.50	600	0.35
WHP018L	18000	10.00	20700	3.80	600	0.85
WHP024A	24000	11.50	27600	4.00	800	0.50
WHP024H	24000	15.00	27600	4.50	800	0.35
WHP024L	24000	10.00	27600	3.80	800	0.85
WHP030A	30000	11.50	34500	4.00	1000	0.50
WHP030H	30000	15.00	34500	4.50	1000	0.35
WHP030L	30000	10.00	34500	3.80	1000	0.85
WHP036A	36000	11.50	41400	4.00	1200	0.50
WHP036H	36000	15.00	41400	4.50	1200	0.35
WHP036L	36000	10.00	41400	3.80	1200	0.85
WHP042A	42000	11.50	48300	4.00	1400	0.50
WHP042H	42000	15.00	48300	4.50	1400	0.35
WHP042L	42000	10.00	48300	3.80	1400	0.85
WHP048A	48000	11.50	55200	4.00	1600	0.50
WHP048H	48000	15.00	55200	4.50	1600	0.35
WHP048L	48000	10.00	55200	3.80	1600	0.85
WHP060A	60000	11.50	69000	4.00	2000	0.50
WHP060H	60000	15.00	69000	4.50	2000	0.35
WHP060L	60000	10.00	69000	3.80	2000	0.85
WHP072A	72000	11.50	82800	4.00	2400	0.50
WHP072H	72000	15.00	82800	4.50	2400	0.35
WHP072L	72000	10.50	82800	3.80	2400	0.85
WHP084A	84000	11.50	96600	4.00	2800	0.50
WHP084H	84000	15.00	96600	4.50	2800	0.35
WHP084L	84000	10.50	96600	3.80	2800	0.85
WHP096A	96000	11.50	110400	4.00	3200	0.50
WHP096H	96000	15.00	110400	4.50	3200	0.35
WHP096L	96000	10.50	110400	3.80	3200	0.85
WHP108A	108000	11.50	124200	4.00	3600	0.50
WHP108H	108000	15.00	124200	4.50	3600	0.35

MODEL	COOLCAP	EER	HEATCAP	COP	CFM	FPI
WHP108L	108000	10.50	124200	3.80	3600	0.85
WHP120A	120000	11.50	138000	4.00	4000	0.50
WHP120H	120000	15.00	138000	4.50	4000	0.35
WHP120L	120000	10.50	138000	3.80	4000	0.85
WHP132A	132000	11.50	151800	4.00	4400	0.50
WHP132H	132000	15.00	151800	4.50	4400	0.35
WHP132L	132000	10.50	151800	3.80	4400	0.85

Table NF-12—ACM EVAPORATIVE EQUIPMENT LIBRARY

Model	Cfm	IndirEff	DirEff	FPI	FPIsup	ACbackUp
EVAP1000AIB	1000	85		0.696	0.500	ACSP58A
EVAP1000AID	1000	85	78	0.696	0.500	
EVAP1000HIB	1000	85		0.546	0.240	ACSP58H
EVAP1000HID	1000	85	78	0.546	0.240	
EVAP1000LIB	1000	85		0.996	0.600	ACSP58L
EVAP1000LID	1000	85	78	0.996	0.600	
EVAP1300AIB	1300	85		0.696	0.500	ACSP63A
EVAP1300AID	1300	85	78	0.696	0.500	
EVAP1300HIB	1300	85		0.546	0.240	ACSP63H
EVAP1300HID	1300	85	78	0.546	0.240	
EVAP1300LIB	1300	85		0.996	0.600	ACSP63L
EVAP1300LID	1300	85	78	0.996	0.600	
EVAP1500AIB	1500	85		0.696	0.500	ACLP007A
EVAP1500AID	1500	85	78	0.696	0.500	
EVAP1500HIB	1500	85		0.546	0.240	ACLP007H
EVAP1500HID	1500	85	78	0.546	0.240	
EVAP1500LIB	1500	85		0.996	0.600	ACLP007L
EVAP1500LID	1500	85	78	0.996	0.600	
EVAP2000AIB	2000	85		0.696	0.500	ACLP007A
EVAP2000AID	2000	85	78	0.696	0.500	
EVAP2000HIB	2000	85		0.546	0.240	ACLP007H
EVAP2000HID	2000	85	78	0.546	0.240	
EVAP2000LIB	2000	85		0.996	0.600	ACLP007L
EVAP2000LID	2000	85	78	0.996	0.600	
EVAP2500AIB	2500	85		0.696	0.500	ACLP007A
EVAP2500AID	2500	85	78	0.696	0.500	
EVAP2500HIB	2500	85		0.546	0.240	ACLP007H
EVAP2500HID	2500	85	78	0.546	0.240	
EVAP2500LIB	2500	85		0.996	0.600	ACLP007L
EVAP2500LID	2500	85	78	0.996	0.600	

Table NF-13—ACM SYSTEM EQUIPMENT LIBRARY

MODEL	COOLCAP	HEATCAP	CFM	FPIcv	FPIav
SYS0025A	25000	33929	893	0.50	1.00
SYS0025H	25000	33929	893	0.35	0.75
SYS0025L	25000	33929	893	0.90	1.35
SYS0038A	38000	51571	1357	0.50	1.00
SYS0038H	38000	51571	1357	0.35	0.75
SYS0038L	38000	51571	1357	0.90	1.35
SYS0050A	50000	67857	1786	0.50	1.00
SYS0050H	50000	67857	1786	0.35	0.75
SYS0050L	50000	67857	1786	0.90	1.35
SYS0063A	63000	85500	2250	0.50	1.00
SYS0063H	63000	85500	2250	0.35	0.75
SYS0063L	63000	85500	2250	0.90	1.35
SYS0075A	75000	101786	2679	0.50	1.00
SYS0075H	75000	101786	2679	0.35	0.75
SYS0075L	75000	101786	2679	0.90	1.35
SYS0088A	88000	119429	3143	0.50	1.00
SYS0088H	88000	119429	3143	0.35	0.75
SYS0088L	88000	119429	3143	0.90	1.35
SYS0100A	100000	135714	3571	0.50	1.00
SYS0100H	100000	135714	3571	0.35	0.75
SYS0100L	100000	135714	3571	0.90	1.35
SYS0125A	125000	169643	4464	0.50	1.00
SYS0125H	125000	169643	4464	0.35	0.75
SYS0125L	125000	169643	4464	0.90	1.35
SYS0188A	188000	255143	6714	0.50	1.00
SYS0188H	188000	255143	6714	0.35	0.75
SYS0188L	188000	255143	6714	0.90	1.35
SYS0250A	250000	339286	8929	0.50	1.00
SYS0250H	250000	339286	8929	0.35	0.75
SYS0250L	250000	339286	8929	0.90	1.35
SYS0380A	380000	515714	13571	0.50	1.00
SYS0380H	380000	515714	13571	0.35	0.75
SYS0380L	380000	515714	13571	0.90	1.35
SYS0500A	500000	678571	17857	0.50	1.00
SYS0500H	500000	678571	17857	0.35	0.75
SYS0500L	500000	678571	17857	0.90	1.35
SYS0625A	625000	848214	22321	0.50	1.00
SYS0625H	625000	848214	22321	0.35	0.75
SYS0625L	625000	848214	22321	0.90	1.35
SYS0750A	750000	1017857	26786	0.50	1.00
SYS0750H	750000	1017857	26786	0.35	0.75
SYS0750L	750000	1017857	26786	0.90	1.35
SYS1000A	1000000	1357143	33000	0.50	1.00
SYS1000H	1000000	1357143	33000	0.35	0.75

MODEL	COOLCAP	HEATCAP	CFM	FPIcv	FPIvav
SYS1000L	1000000	1357143	33000	0.90	1.35

Table NF-14—ACM ELECTRICAL CHILLER LIBRARY

Model	CoolCap	COP
COOL0180A	180000	4.00
COOL0180H	180000	4.20
COOL0180L	180000	3.80
COOL0240A	240000	4.00
COOL0240H	240000	4.20
COOL0240L	240000	3.80
COOL0300A	300000	4.00
COOL0300H	300000	4.20
COOL0300L	300000	3.80
COOL0360A	360000	4.00
COOL0360H	360000	4.20
COOL0360L	360000	3.80
COOL0480A	480000	4.00
COOL0480H	480000	4.20
COOL0480L	480000	3.80
COOL0900A	900000	4.00
COOL0900H	900000	4.20
COOL0900L	900000	3.80
COOL1200A	1200000	4.00
COOL1200H	1200000	4.20
COOL1200L	1200000	3.80
COOL1800A	1800000	4.40
COOL1800H	1800000	4.60
COOL1800L	1800000	4.20
COOL2100A	2100000	4.40
COOL2100H	2100000	4.60
COOL2100L	2100000	4.20
COOL2400A	2400000	4.40
COOL2400H	2400000	4.60
COOL2400L	2400000	4.20
COOL3000A	3000000	4.40
COOL3000H	3000000	4.60
COOL3000L	3000000	4.20
COOL3600A	3600000	5.60
COOL3600H	3600000	5.80
COOL3600L	3600000	5.20
COOL4200A	4200000	5.60
COOL4200H	4200000	5.80
COOL4200L	4200000	5.20

Table NF-15—ACM ABSORPTION CHILLER LIBRARY

Model	Cooling Capacity	HIR	EIR
ABSOR10180A	180000	1.60	0.0040
ABSOR10180H	180000	1.55	0.0035
ABSOR10180L	180000	1.65	0.0045
ABSOR10240A	240000	1.60	0.0040
ABSOR10240H	240000	1.55	0.0035
ABSOR10240L	240000	1.65	0.0045
ABSOR10300A	300000	1.60	0.0040
ABSOR10300H	300000	1.55	0.0035
ABSOR10300L	300000	1.65	0.0045
ABSOR10360A	360000	1.60	0.0040
ABSOR10360H	360000	1.55	0.0035
ABSOR10360L	360000	1.65	0.0045
ABSOR10480A	480000	1.60	0.0040
ABSOR10480H	480000	1.55	0.0035
ABSOR10480L	480000	1.65	0.0045
ABSOR10900A	900000	1.60	0.0040
ABSOR10900H	900000	1.55	0.0035
ABSOR10900L	900000	1.65	0.0045
ABSOR11200A	1200000	1.60	0.0040
ABSOR11200H	1200000	1.65	0.0035
ABSOR11200L	1200000	1.55	0.0045
ABSOR11800A	1800000	1.60	0.0040
ABSOR11800H	1800000	1.55	0.0035
ABSOR11800L	1800000	1.65	0.0045
ABSOR12100A	2100000	1.60	0.0040
ABSOR12100H	2100000	1.55	0.0035
ABSOR12100L	2100000	1.65	0.0045
ABSOR12400A	2400000	1.60	0.0040
ABSOR12400H	2400000	1.55	0.0035
ABSOR12400L	2400000	1.65	0.0045
ABSOR13000A	3000000	1.60	0.0040
ABSOR13000H	3000000	1.55	0.0035
ABSOR13000L	3000000	1.65	0.0045
ABSOR13600A	3600000	1.60	0.0040
ABSOR13600H	3600000	1.55	0.0035
ABSOR13600L	3600000	1.65	0.0045
ABSOR14200A	4200000	1.60	0.0040
ABSOR14200H	4200000	1.55	0.0035
ABSOR14200L	4200000	1.65	0.0045
ABSOR20180A	180000	1.00	0.0070
ABSOR20180H	180000	1.00	0.0065
ABSOR20180L	180000	1.00	0.0075
ABSOR20240A	240000	1.00	0.0070
ABSOR20240H	240000	1.00	0.0065

Model	Cooling Capacity	HIR	EIR
ABSOR20240L	240000	1.00	0.0075
ABSOR20360A	360000	1.00	0.0070
ABSOR20360H	360000	1.00	0.0065
ABSOR20360L	360000	1.00	0.0075
ABSOR20480A	480000	1.00	0.0070
ABSOR20480H	480000	1.00	0.0065
ABSOR20480L	480000	1.00	0.0075
ABSOR20900A	900000	1.00	0.0070
ABSOR20900H	900000	1.00	0.0065
ABSOR20900L	900000	1.00	0.0075
ABSOR21200A	1200000	1.00	0.0070
ABSOR21200H	1200000	1.00	0.0065
ABSOR21200L	1200000	1.00	0.0075
ABSOR21800A	1800000	1.00	0.0070
ABSOR21800H	1800000	1.00	0.0065
ABSOR21800L	1800000	1.00	0.0075
ABSOR22100A	2100000	1.00	0.0070
ABSOR22100H	2100000	1.00	0.0065
ABSOR22100L	2100000	1.00	0.0075
ABSOR22400A	2400000	1.00	0.0070
ABSOR22400H	2400000	1.00	0.0065
ABSOR22400L	2400000	1.00	0.0075
ABSOR23000A	3000000	1.00	0.0070
ABSOR23000H	3000000	1.00	0.0065
ABSOR23000L	3000000	1.00	0.0075
ABSOR23600A	3600000	1.00	0.0070
ABSOR23600H	3600000	1.00	0.0065
ABSOR23600L	3600000	1.00	0.0075
ABSOR24200A	4200000	1.00	0.0070
ABSOR24200H	4200000	1.00	0.0065
ABSOR24200L	4200000	1.00	0.0075
ABSORG0180A	180000	1.00	0.0071
ABSORG0180H	180000	1.00	0.0066
ABSORG0180L	180000	1.00	0.0076
ABSORG0240A	240000	1.00	0.0071
ABSORG0240H	240000	1.00	0.0066
ABSORG0240L	240000	1.00	0.0076
ABSORG0360A	360000	1.00	0.0071
ABSORG0360H	360000	1.00	0.0066
ABSORG0360L	360000	1.00	0.0076
ABSORG0480A	480000	1.00	0.0071
ABSORG0480H	480000	1.00	0.0066
ABSORG0480L	480000	1.00	0.0076
ABSORG0900A	900000	1.00	0.0071
ABSORG0900H	900000	1.00	0.0066
ABSORG0900L	900000	1.00	0.0076

Model	Cooling Capacity	HIR	EIR
ABSORG1200A	1200000	1.00	0.0071
ABSORG1200H	1200000	1.00	0.0066
ABSORG1200L	1200000	1.00	0.0076
ABSORG1800A	1800000	1.00	0.0071
ABSORG1800H	1800000	1.00	0.0066
ABSORG1800L	1800000	1.00	0.0076
ABSORG2100A	2100000	1.00	0.0071
ABSORG2100H	2100000	1.00	0.0066
ABSORG2100L	2100000	1.00	0.0076
ABSORG2400A	2400000	1.00	0.0071
ABSORG2400H	2400000	1.00	0.0066
ABSORG2400L	2400000	1.00	0.0076
ABSORG3000A	3000000	1.00	0.0071
ABSORG3000H	3000000	1.00	0.0066
ABSORG3000L	3000000	1.00	0.0076
ABSORG3600A	3600000	1.00	0.0071
ABSORG3600H	3600000	1.00	0.0066
ABSORG3600L	3600000	1.00	0.0076
ABSORG4200A	4200000	1.00	0.0071
ABSORG4200H	4200000	1.00	0.0066
ABSORG4200L	4200000	1.00	0.0076

Table NF-16—ACM TOWER LIBRARY

Model	CoolCap
TOWER0220	220000
TOWER0260	260000
TOWER0330	330000
TOWER0390	390000
TOWER0500	500000
TOWER0930	930000
TOWER1250	1250000
TOWER1870	1870000
TOWER2160	2160000
TOWER2480	2480000
TOWER3100	3100000
TOWER3700	3700000
TOWER4300	4300000

Table NF-17- ACM BOILER LIBRARY

Model	Size	Afue
BOILER00100A	100000	82
BOILER00100H	100000	84
BOILER00100L	100000	80
BOILER00250A	250000	82
BOILER00250H	250000	84
BOILER00250L	250000	80
BOILER00500A	500000	82
BOILER00500H	500000	84
BOILER00500L	500000	80
BOILER00750A	750000	82
BOILER00750H	750000	84
BOILER00750L	750000	80
BOILER01000A	1000000	82
BOILER01000H	1000000	84
BOILER01000L	1000000	80
BOILER01500A	1500000	82
BOILER01500H	1500000	84
BOILER01500L	1500000	80
BOILER02000A	2000000	82
BOILER02000H	2000000	84
BOILER02000L	2000000	80
BOILER02500A	2500000	82
BOILER02500H	2500000	84
BOILER02500L	2500000	80
BOILER03000A	3000000	82
BOILER03000H	3000000	84
BOILER03000L	3000000	80

Table NF-18– ACM VAV BOX SELECTED

Test	System	Zone	Model
A12B13	SYS-1	EAST1	VAV900A
A12B13	SYS-1	EAST2	VAV1200A
A12B13	SYS-1	NORTH1	VAV900A
A12B13	SYS-1	NORTH2	VAV900A
A12B13	SYS-1	SOUTH1	VAV1500A
A12B13	SYS-1	SOUTH2	VAV1500A
A12B13	SYS-1	WEST1	VAV1200A
A12B13	SYS-1	WEST2	VAV1200A
A13B06	SYS-1	EAST1	VAV900A
A13B06	SYS-1	EAST2	VAV1200A
A13B06	SYS-1	NORTH1	VAV600A
A13B06	SYS-1	NORTH2	VAV900A
A13B06	SYS-1	SOUTH1	VAV1200A
A13B06	SYS-1	SOUTH2	VAV1500A
A13B06	SYS-1	WEST1	VAV1200A
A13B06	SYS-1	WEST2	VAV1200A
A14B16	SYS-1	EAST1	VAV900A
A14B16	SYS-1	EAST2	VAV900A
A14B16	SYS-1	NORTH1	VAV600A
A14B16	SYS-1	NORTH2	VAV900A
A14B16	SYS-1	SOUTH1	VAV1200A
A14B16	SYS-1	SOUTH2	VAV1500A
A14B16	SYS-1	WEST1	VAV900A
A14B16	SYS-1	WEST2	VAV1200A
A17B16	SYS-1	EAST1	VAV900A
A17B16	SYS-1	EAST2	VAV900A
A17B16	SYS-1	NORTH1	VAV600A
A17B16	SYS-1	NORTH2	VAV600A
A17B16	SYS-1	SOUTH1	VAV900A
A17B16	SYS-1	SOUTH2	VAV900A
A17B16	SYS-1	WEST1	VAV900A
A17B16	SYS-1	WEST2	VAV900A
B11B13	SYS-1	EAST1	VAV1500L
B11B13	SYS-1	EAST2	VAV2000L
B11B13	SYS-1	NORTH1	VAV1200L
B11B13	SYS-1	NORTH2	VAV1200L
B11B13	SYS-1	SOUTH1	VAV2000L
B11B13	SYS-1	SOUTH2	VAV2000L
B11B13	SYS-1	WEST1	VAV2000L
B11B13	SYS-1	WEST2	VAV2000L
B12B13	SYS-1	EAST1	VAV2000L
B12B13	SYS-1	EAST2	VAV2000L
B12B13	SYS-1	NORTH1	VAV1200L
B12B13	SYS-1	NORTH2	VAV1500L

Test	System	Zone	Model
B12B13	SYS-1	SOUTH1	VAV2000L
B12B13	SYS-1	SOUTH2	VAV2500L
B12B13	SYS-1	WEST1	VAV2000L
B12B13	SYS-1	WEST2	VAV2000L
B13B13	SYS-1	EAST1	VAV2000L
B13B13	SYS-1	EAST2	VAV2000L
B13B13	SYS-1	NORTH1	VAV1200L
B13B13	SYS-1	NORTH2	VAV1200L
B13B13	SYS-1	SOUTH1	VAV2500L
B13B13	SYS-1	SOUTH2	VAV2500L
B13B13	SYS-1	WEST1	VAV2000L
B13B13	SYS-1	WEST2	VAV2500L
B14B06	SYS-1	EAST1	VAV2000H
B14B06	SYS-1	EAST2	VAV2000H
B14B06	SYS-1	NORTH1	VAV1200H
B14B06	SYS-1	NORTH2	VAV1200H
B14B06	SYS-1	SOUTH1	VAV2000H
B14B06	SYS-1	SOUTH2	VAV2500H
B14B06	SYS-1	WEST1	VAV2000H
B14B06	SYS-1	WEST2	VAV2000H
B15B16	SYS-1	EAST1	VAV2000H
B15B16	SYS-1	EAST2	VAV2000H
B15B16	SYS-1	NORTH1	VAV900H
B15B16	SYS-1	NORTH2	VAV1200H
B15B16	SYS-1	SOUTH1	VAV2000H
B15B16	SYS-1	SOUTH2	VAV2500H
B15B16	SYS-1	WEST1	VAV2000H
B15B16	SYS-1	WEST2	VAV2500H
B21B12	SYS-1	EAST1	VAV1500A
B21B12	SYS-1	EAST2	VAV1500A
B21B12	SYS-1	NORTH1	VAV1200A
B21B12	SYS-1	NORTH2	VAV1200A
B21B12	SYS-1	SOUTH1	VAV1500A
B21B12	SYS-1	SOUTH2	VAV2000A
B21B12	SYS-1	WEST1	VAV2000A
B21B12	SYS-1	WEST2	VAV2000A
B22B12	SYS-1	EAST1	VAV1200A
B22B12	SYS-1	EAST2	VAV1200A
B22B12	SYS-1	NORTH1	VAV1200A
B22B12	SYS-1	NORTH2	VAV1200A
B22B12	SYS-1	SOUTH1	VAV1500A
B22B12	SYS-1	SOUTH2	VAV1500A
B22B12	SYS-1	WEST1	VAV1500A
B22B12	SYS-1	WEST2	VAV1500A
B23B12	SYS-1	EAST1	VAV1200A
B23B12	SYS-1	EAST2	VAV1200A

Test	System	Zone	Model
B23B12	SYS-1	NORTH1	VAV900A
B23B12	SYS-1	NORTH2	VAV1200A
B23B12	SYS-1	SOUTH1	VAV1500A
B23B12	SYS-1	SOUTH2	VAV1500A
B23B12	SYS-1	WEST1	VAV1500A
B23B12	SYS-1	WEST2	VAV1500A
B24B03	SYS-1	EAST1	VAV1200A
B24B03	SYS-1	EAST2	VAV1200A
B24B03	SYS-1	NORTH1	VAV900A
B24B03	SYS-1	NORTH2	VAV900A
B24B03	SYS-1	SOUTH1	VAV1200A
B24B03	SYS-1	SOUTH2	VAV1200A
B24B03	SYS-1	WEST1	VAV1200A
B24B03	SYS-1	WEST2	VAV1500A
C21B10	SYS-1	EAST2	VAV2000A
C21B10	SYS-1	NORTH1	VAV1500A
C21B10	SYS-1	NORTH2	VAV1200A
C21B10	SYS-1	SOUTH1	VAV2500A
C21B10	SYS-1	SOUTH2	VAV2500A
C21B10	SYS-1	WEST2	VAV2000A
C21B10	SYS-2	INT1	VAV600A
C21B10	SYS-2	INT2	VAV900A
C22C16	SYS-1	ZONE1E	VAV1500A
C22C16	SYS-1	ZONE1I	VAV900A
C22C16	SYS-1	ZONE1N	VAV1200A
C22C16	SYS-1	ZONE1S	VAV1500A
C22C16	SYS-1	ZONE3I	VAV900A
C22C16	SYS-1	ZONE3S	VAV1200A
C22C16	SYS-2	ZONE1W	VAV1500A
C22C16	SYS-2	ZONE3E	VAV2000A
C22C16	SYS-2	ZONE3N	VAV1200A
C22C16	SYS-2	ZONE3W	VAV2000A
E21B16	SYS-1	EAST1	VAV1200A
E21B16	SYS-1	EAST2	VAV1200A
E21B16	SYS-1	INT1	VAV900A
E21B16	SYS-1	INT2	VAV900A
E21B16	SYS-1	NORTH1	VAV600A
E21B16	SYS-1	NORTH2	VAV900A
E21B16	SYS-1	SOUTH1	VAV1500A
E21B16	SYS-1	SOUTH2	VAV1500A
E21B16	SYS-1	WEST1	VAV1200A
E21B16	SYS-1	WEST2	VAV1200A
E22B16	SYS-1	EAST1	VAV1200A
E22B16	SYS-1	EAST2	VAV1200A
E22B16	SYS-1	INT1	VAV900A
E22B16	SYS-1	INT2	VAV900A

Test	System	Zone	Model
E22B16	SYS-1	NORTH1	VAV900A
E22B16	SYS-1	NORTH2	VAV900A
E22B16	SYS-1	SOUTH1	VAV1500A
E22B16	SYS-1	SOUTH2	VAV1500A
E22B16	SYS-1	WEST1	VAV1200A
E22B16	SYS-1	WEST2	VAV1500A
E23B16	SYS-1	EAST1	VAV1200A
E23B16	SYS-1	EAST2	VAV1200A
E23B16	SYS-1	INT1	VAV900A
E23B16	SYS-1	INT2	VAV1200A
E23B16	SYS-1	NORTH1	VAV900A
E23B16	SYS-1	NORTH2	VAV900A
E23B16	SYS-1	SOUTH1	VAV1500A
E23B16	SYS-1	SOUTH2	VAV1500A
E23B16	SYS-1	WEST1	VAV1500A
E23B16	SYS-1	WEST2	VAV1500A
E24B12	SYS-1	EAST1	VAV1200H
E24B12	SYS-1	EAST2	VAV1200H
E24B12	SYS-1	INT1	VAV900H
E24B12	SYS-1	INT2	VAV900H
E24B12	SYS-1	NORTH1	VAV900H
E24B12	SYS-1	NORTH2	VAV900H
E24B12	SYS-1	SOUTH1	VAV2000H
E24B12	SYS-1	SOUTH2	VAV2000H
E24B12	SYS-1	WEST1	VAV1500H
E24B12	SYS-1	WEST2	VAV2000H
E25B12	SYS-1	EAST1	VAV1200H
E25B12	SYS-1	EAST2	VAV1500H
E25B12	SYS-1	INT1	VAV900H
E25B12	SYS-1	INT2	VAV900H
E25B12	SYS-1	NORTH1	VAV900H
E25B12	SYS-1	NORTH2	VAV1200H
E25B12	SYS-1	SOUTH1	VAV2000H
E25B12	SYS-1	SOUTH2	VAV2000H
E25B12	SYS-1	WEST1	VAV1500H
E25B12	SYS-1	WEST2	VAV2000H
E26B12	SYS-1	EAST1	VAV1500H
E26B12	SYS-1	EAST2	VAV1500H
E26B12	SYS-1	INT1	VAV900H
E26B12	SYS-1	INT2	VAV1200H
E26B12	SYS-1	NORTH1	VAV1200H
E26B12	SYS-1	NORTH2	VAV1200H
E26B12	SYS-1	SOUTH1	VAV2000H
E26B12	SYS-1	SOUTH2	VAV2000H
E26B12	SYS-1	WEST1	VAV1500H
E26B12	SYS-1	WEST2	VAV2000H

Test	System	Zone	Model
F13B12	SYS-1	EAST1	VAV2000H
F13B12	SYS-1	EAST2	VAV2000H
F13B12	SYS-1	NORTH1	VAV1200H
F13B12	SYS-1	NORTH2	VAV1500H
F13B12	SYS-1	SOUTH1	VAV2000H
F13B12	SYS-1	SOUTH2	VAV2500H
F13B12	SYS-1	WEST1	VAV2000H
F13B12	SYS-1	WEST2	VAV2000H
F14B12	SYS-1	EAST1	VAV1500H
F14B12	SYS-1	EAST2	VAV2000H
F14B12	SYS-1	NORTH1	VAV1200H
F14B12	SYS-1	NORTH2	VAV1200H
F14B12	SYS-1	SOUTH1	VAV2000H
F14B12	SYS-1	SOUTH2	VAV2000H
F14B12	SYS-1	WEST1	VAV2000H
F14B12	SYS-1	WEST2	VAV2000H
G15B03	SYS-1	EAST1	VAV3000A
G15B03	SYS-1	EAST2	VAV3500A
G15B03	SYS-1	NORTH1	VAV2000A
G15B03	SYS-1	NORTH2	VAV2000A
G15B03	SYS-1	SOUTH1	VAV3500A
G15B03	SYS-1	SOUTH2	VAV4000A
G15B03	SYS-1	WEST1	VAV3500A
G15B03	SYS-1	WEST2	VAV3500A
G15B03	SYS-2	INT1	VAV300A
G15B03	SYS-2	INT2	VAV450A
G16B16	SYS-1	EAST1	VAV600A
G16B16	SYS-1	EAST2	VAV900A
G16B16	SYS-1	NORTH1	VAV450A
G16B16	SYS-1	NORTH2	VAV450A
G16B16	SYS-1	SOUTH1	VAV900A
G16B16	SYS-1	SOUTH2	VAV900A
G16B16	SYS-1	WEST1	VAV900A
G16B16	SYS-1	WEST2	VAV900A
G16B16	SYS-2	INT1	VAV1200A
G16B16	SYS-2	INT2	VAV1500A
O21B13	SYS-1	EAST1	VAV2000A
O21B13	SYS-1	EAST2	VAV2000A
O21B13	SYS-1	INT1	VAV900A
O21B13	SYS-1	INT2	VAV1200A
O21B13	SYS-1	NORTH1	VAV1200A
O21B13	SYS-1	NORTH2	VAV1500A
O21B13	SYS-1	SOUTH1	VAV2000A
O21B13	SYS-1	SOUTH2	VAV2500A
O21B13	SYS-1	WEST1	VAV2000A
O21B13	SYS-1	WEST2	VAV2000A

Test	System	Zone	Model
O22B13	SYS-1	EAST1	VAV2000A
O22B13	SYS-1	EAST2	VAV2000A
O22B13	SYS-1	INT1	VAV900A
O22B13	SYS-1	INT2	VAV1200A
O22B13	SYS-1	NORTH1	VAV1200A
O22B13	SYS-1	NORTH2	VAV1500A
O22B13	SYS-1	SOUTH1	VAV2000A
O22B13	SYS-1	SOUTH2	VAV2500A
O22B13	SYS-1	WEST1	VAV2000A
O22B13	SYS-1	WEST2	VAV2000A
O23B13	SYS-1	EAST1	VAV2000A
O23B13	SYS-1	EAST2	VAV2000A
O23B13	SYS-1	INT1	VAV900A
O23B13	SYS-1	INT2	VAV1200A
O23B13	SYS-1	NORTH1	VAV1200A
O23B13	SYS-1	NORTH2	VAV1500A
O23B13	SYS-1	SOUTH1	VAV2000A
O23B13	SYS-1	SOUTH2	VAV2500A
O23B13	SYS-1	WEST1	VAV2000A
O23B13	SYS-1	WEST2	VAV2000A
O24B13	SYS-1	EAST1	VAV2000A
O24B13	SYS-1	EAST2	VAV2000A
O24B13	SYS-1	INT1	VAV900A
O24B13	SYS-1	INT2	VAV1200A
O24B13	SYS-1	NORTH1	VAV1200A
O24B13	SYS-1	NORTH2	VAV1500A
O24B13	SYS-1	SOUTH1	VAV2000A
O24B13	SYS-1	SOUTH2	VAV2500A
O24B13	SYS-1	WEST1	VAV2000A
O24B13	SYS-1	WEST2	VAV2000A
O41B13	SYS-1	EAST1	VAV2000L
O41B13	SYS-1	EAST2	VAV2000L
O41B13	SYS-1	INT1	VAV900L
O41B13	SYS-1	INT2	VAV1200L
O41B13	SYS-1	NORTH1	VAV1200L
O41B13	SYS-1	NORTH2	VAV1500L
O41B13	SYS-1	SOUTH1	VAV2000L
O41B13	SYS-1	SOUTH2	VAV2500L
O41B13	SYS-1	WEST1	VAV2000L
O41B13	SYS-1	WEST2	VAV2000L
O61B11	SYS-1	EAST1	VAV2000A
O61B11	SYS-1	EAST2	VAV2000A
O61B11	SYS-1	INT1	VAV900A
O61B11	SYS-1	INT2	VAV1200A
O61B11	SYS-1	NORTH1	VAV1200A
O61B11	SYS-1	NORTH2	VAV1500A

Test	System	Zone	Model
O61B11	SYS-1	SOUTH1	VAV2000A
O61B11	SYS-1	SOUTH2	VAV2500A
O61B11	SYS-1	WEST1	VAV2000A
O61B11	SYS-1	WEST2	VAV2000A
O62B11	SYS-1	EAST1	VAV2000A
O62B11	SYS-1	EAST2	VAV2000A
O62B11	SYS-1	INT1	VAV900A
O62B11	SYS-1	INT2	VAV1200A
O62B11	SYS-1	NORTH1	VAV1200A
O62B11	SYS-1	NORTH2	VAV1500A
O62B11	SYS-1	SOUTH1	VAV2000A
O62B11	SYS-1	SOUTH2	VAV2500A
O62B11	SYS-1	WEST1	VAV2000A
O62B11	SYS-1	WEST2	VAV2000A
O63B11	SYS-1	EAST1	VAV2000A
O63B11	SYS-1	EAST2	VAV2000A
O63B11	SYS-1	INT1	VAV900A
O63B11	SYS-1	INT2	VAV1200A
O63B11	SYS-1	NORTH1	VAV1200A
O63B11	SYS-1	NORTH2	VAV1500A
O63B11	SYS-1	SOUTH1	VAV2000A
O63B11	SYS-1	SOUTH2	VAV2500A
O63B11	SYS-1	WEST1	VAV2000A
O63B11	SYS-1	WEST2	VAV2000A
O64B11	SYS-1	EAST1	VAV2000A
O64B11	SYS-1	EAST2	VAV2000A
O64B11	SYS-1	INT1	VAV900A
O64B11	SYS-1	INT2	VAV1200A
O64B11	SYS-1	NORTH1	VAV1200A
O64B11	SYS-1	NORTH2	VAV1500A
O64B11	SYS-1	SOUTH1	VAV2000A
O64B11	SYS-1	SOUTH2	VAV2500A
O64B11	SYS-1	WEST1	VAV2000A
O64B11	SYS-1	WEST2	VAV2000A
O65B11	SYS-1	EAST1	VAV2000A
O65B11	SYS-1	EAST2	VAV2000A
O65B11	SYS-1	INT1	VAV900A
O65B11	SYS-1	INT2	VAV1200A
O65B11	SYS-1	NORTH1	VAV1200A
O65B11	SYS-1	NORTH2	VAV1500A
O65B11	SYS-1	SOUTH1	VAV2000A
O65B11	SYS-1	SOUTH2	VAV2500A
O65B11	SYS-1	WEST1	VAV2000A
O65B11	SYS-1	WEST2	VAV2000A
O66B12	SYS-1	EAST1	VAV2000A
O66B12	SYS-1	EAST2	VAV2000A

Test	System	Zone	Model
O66B12	SYS-1	INT1	VAV900A
O66B12	SYS-1	INT2	VAV1200A
O66B12	SYS-1	NORTH1	VAV1200A
O66B12	SYS-1	NORTH2	VAV1500A
O66B12	SYS-1	SOUTH1	VAV2000A
O66B12	SYS-1	SOUTH2	VAV2500A
O66B12	SYS-1	WEST1	VAV2000A
O66B12	SYS-1	WEST2	VAV2000A

Table NF-19 – ACM PACKAGE UNITS SELECTED

Test	System	Model
A11B13	SYS-1	ACSP34L
A11B13	SYS-2	ACSP34L
A11B13	SYS-3	ACSP34L
A11B13	SYS-4	ACSP34L
A11B13	SYS-5	ACSP34L
A11B13	SYS-6	ACSP34L
A11B13	SYS-7	ACSP34L
A11B13	SYS-8	ACSP34L
A12B13	SYS-1	ACLP025A
A13B06	SYS-1	ACLP020A
A14B16	SYS-1	ACLP020A
A15B03	SYS-1	ACSP28L
A15B03	SYS-2	ACSP28L
A15B03	SYS-3	ACSP28L
A15B03	SYS-4	ACSP28L
A15B03	SYS-5	ACSP28L
A15B03	SYS-6	ACSP28L
A15B03	SYS-7	ACSP28L
A15B03	SYS-8	ACSP28L
A16B13	SYS-1	ACSP28L
A16B13	SYS-2	ACSP28L
A16B13	SYS-3	ACSP28L
A16B13	SYS-4	ACSP28L
A16B13	SYS-5	ACSP28L
A16B13	SYS-6	ACSP28L
A16B13	SYS-7	ACSP28L
A16B13	SYS-8	ACSP28L
A17B16	SYS-1	ACLP015A
B11B13	SYS-1	ACLP040L
B12B13	SYS-1	ACLP040L
B13B13	SYS-1	ACLP040L
B14B06	SYS-1	ACLP040H
B15B16	SYS-1	ACLP040H
B21B12	SYS-1	ACLP030A
B22B12	SYS-1	ACLP025A
B23B12	SYS-1	ACLP030A
B24B03	SYS-1	ACLP025A
B31D12	SYS-1	ACLP007A
B32D12	SYS-1	ACLP007A
C11A10	SYS-1	ACLP015A
C12A10	SYS-1	ACLP015A
C13A10	SYS-1	ACLP025A
C14A10	SYS-1	ACLP010A
C15A10	SYS-1	ACLP010A

Test	System	Model
C21B10	SYS-1	ACLP030A
C21B10	SYS-2	ACSP46A
C21B10	SYS-3	HEAT045A
C21B10	SYS-4	HEAT063A
D11D12	SYS-1	ACSP63A
D12D12	SYS-1	ACSP63A
D13D07	SYS-1	ACSP52A
D14D07	SYS-1	ACSP52A
E11D16	SYS-1	ACSP22A
E12D16	SYS-1	ACSP28A
E13D16	SYS-1	ACSP28A
E14D14	SYS-1	ACSP40A
E15D14	SYS-1	ACSP40A
E16D14	SYS-1	ACSP52A
E21B16	SYS-1	ACLP025A
E22B16	SYS-1	ACLP030A
E23B16	SYS-1	ACLP030A
E24B12	SYS-1	ACLP030H
E25B12	SYS-1	ACLP040H
E26B12	SYS-1	ACLP040H
F13B12	SYS-1	ACLP040H
F14B12	SYS-1	ACLP040H
G11A11	SYS-1	ACLP025A
G12A11	SYS-1	ACLP007A
G15B03	SYS-1	ACLP015A
G15B03	SYS-2	ACLP007A
G16B16	SYS-1	ACLP060A
G16B16	SYS-2	ACSP22A
O31A12	SYS-1	ACLP015A
O32A12	SYS-1	ACLP010H
O33A12	SYS-1	ACLP010H
O41B13	SYS-1	ACLP040L
O81A11	SYS-1	ACLP015A
O82A15	SYS-1	ACLP015A
OC1A09	SYS-1	NOHVAC
OC2A09	SYS-1	NOHVAC
OC3A09	SYS-1	ACLP015H
OC4A09	SYS-1	ACLP010A
OC4A09	SYS-2	ACLP010A

Table NF-20 – ACM WATER LOOP HEAT PUMP SELECTED

Test	System	Zone	Model
O71B12	SYS-1	EAST1	WHP060A
O71B12	SYS-1	EAST2	WHP060A
O71B12	SYS-1	INT1	WHP036A
O71B12	SYS-1	INT2	WHP042A
O71B12	SYS-1	NORTH1	WHP042A
O71B12	SYS-1	NORTH2	WHP042A
O71B12	SYS-1	SOUTH1	WHP072A
O71B12	SYS-1	SOUTH2	WHP072A
O71B12	SYS-1	WEST1	WHP060A
O71B12	SYS-1	WEST2	WHP072A

Table NF-21 – ACM EVAPORATIVE COOLING EQUIPMENT SELECTED

Test	System	Model
O91A13	SYS-1	EVAP2500AIB
O92A11	SYS-1	EVAP2500AID
O93A11	SYS-1	EVAP2500AID
O94A13	SYS-1	EVAP2500AID

Table NF-22 – FAN COIL UNITS SELECTED

Test	System	Zone	Model
C22C16	SYS-3	ZONE2E	FC035A
C22C16	SYS-3	ZONE2I	FC013A
C22C16	SYS-3	ZONE2N	FC021A
C22C16	SYS-3	ZONE2S	FC056A
C22C16	SYS-3	ZONE2W	FC042A

Table NF-23 – ACM HEAT PUMP EQUIPMENT SELECTED

Test	System	Model
F11A07	SYS-1	HPSP126H
F12A13	SYS-1	HPSP162A
G13A11	SYS-1	HPSP222H
G14A11	SYS-1	HPSP90A

Table NF-24 – ACM SYSTEM EQUIPMENT SELECTED

Test	System	Model
C22C16	SYS-1	SYS0250A
C22C16	SYS-2	SYS0250A
O21B13	SYS-1	SYS0500A
O22B13	SYS-1	SYS0500A
O23B13	SYS-1	SYS0500A
O24B13	SYS-1	SYS0500A
O61B11	SYS-1	SYS0625A
O62B11	SYS-1	SYS0625A
O63B11	SYS-1	SYS0625A
O64B11	SYS-1	SYS0625A
O65B11	SYS-1	SYS0625A
O66B12	SYS-1	SYS0500A

Table NF-25 – ACM CENTRAL COOLING EQUIPMENT SELECTED

Test	Model
C22C16	COOL0900A
C22C16	TOWER0930
O21B13	COOL0480A
O21B13	TOWER0930
O22B13	COOL0480A
O22B13	TOWER0930
O23B13	COOL0480A
O23B13	TOWER0930
O24B13	COOL0480A
O24B13	TOWER0930
O61B11	ABSOR10480A
O61B11	TOWER1250
O62B11	ABSOR20480A
O62B11	TOWER0930
O63B11	ABSORG0480A
O63B11	TOWER0930
O64B11	COOL0480A
O64B11	TOWER0930
O65B11	COOL0480A
O65B11	TOWER0930
O66B12	COOL0480A
O66B12	TOWER0930
O71B12	TOWER0220
O71B12	TOWER0930
O71B12	TOWER4300

Table NF-26 – ACM BOILER SELECTION

Test	Model
A12B13	BOILER00250A
A13B06	BOILER00250A
A14B16	BOILER00250A
A17B16	BOILER00250A
B11B13	BOILER00500L
B12B13	BOILER00500L
B13B13	BOILER00500L
B14B06	BOILER00250H
B15B16	BOILER00250H
B21B12	BOILER00250A
B22B12	BOILER00250A
B23B12	BOILER00250A
B24B03	BOILER00250A
C21B10	NOBOILER
C22C16	BOILER01000A
E21B16	BOILER00250A
E22B16	BOILER00250A
E23B16	BOILER00500A
E24B12	BOILER00250H
E25B12	BOILER00250H
E26B12	BOILER00250H
F13B12	NOBOILER
F14B12	NOBOILER
G15B03	NOBOILER
G16B16	NOBOILER
O21B13	BOILER00500A
O22B13	BOILER00500A
O23B13	BOILER00500A
O24B13	BOILER00500A
O41B13	BOILER00500L
O61B11	BOILER01500A
O62B11	BOILER00750A
O63B11	BOILER00500A
O64B11	BOILER00500A
O65B11	BOILER00500A
O66B12	BOILER00500A
O71B12	BOILER00500A

ACM NG-2005

Appendix NG - Standard Procedure for Determining the Seasonal Energy Efficiencies of Single-Zone Nonresidential Air Distribution Systems in Buffer Spaces or Outdoors ~~the Space Between an Insulated Ceiling and the Roof~~

NG.1 Purpose and Scope

ACM NG contains procedures for measuring the air leakage in single zone, nonresidential air distribution systems and for calculating the annual and hourly duct system efficiency for energy calculations. The methods described here apply to single zone, constant volume heating and air conditioning systems serving zones with 5000 ft² of floor area or less, with duct systems located in unconditioned or semi-conditioned buffer spaces or outdoors. These calculations apply to new buildings or new air conditioning systems applied to existing buildings.

NG.1 Introduction

This appendix describes the measurement and calculation methods for determining air distribution system efficiency for single zone non residential air distribution systems in the space between an insulated ceiling and the roof.

NG.2 Definitions

aerosol sealant closure system: A method of sealing leaks by blowing aerosolized sealant particles into the duct system ~~and~~ which must include minute-by-minute documentation of the sealing process.

buffer space: an unconditioned or indirectly conditioned space located between a ceiling and the roof.

floor area: The floor area of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces enclosing the conditioned space.

cool roof: a roofing material with high thermal emittance and high solar reflectance, or lower thermal emittance and exceptionally high solar reflectance as specified in Standards § 118 (i) that reduces heat gain through the roof.

delivery effectiveness: The ratio of the thermal energy delivered to the conditioned space and the thermal energy entering the distribution system at the equipment heat exchanger.

distribution system efficiency: The ratio of the thermal energy consumed by the equipment with the distribution system to the energy consumed if the distribution system had no losses or impact on the equipment or building loads.

equipment efficiency: The ratio between the thermal energy entering the distribution system at the equipment heat exchanger and the energy being consumed by the equipment.

equipment factor : F_{equip} is the ratio of the equipment efficiency including the effects of the distribution system to the equipment efficiency of the equipment in isolation.

fan flowmeter device: A device used to measure air flow rates under a range of test pressure differences.

floor area: The floor area of enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces enclosing the conditioned space.

Flow capture hood: A device used to capture and measure the airflow at a register.

load factor : F_{load} is the ratio of the building energy load without including distribution effects to the load including distribution system effects.

pressure pan : a device used to seal individual forced air system registers and to measure the static pressure from the register.

radiant barrier : a surface of low emissivity (less than 0.05) placed inside an attic or roof space to reduce radiant heat transfer.

recovery factor : F_{recov} is the fraction of energy lost from the distribution system that enters the conditioned space.

thermal regain: The fraction of delivery system losses that are returned to the building.

NG.3 Nomenclature

a_r = duct leakage factor (1-return leakage) for return ducts

a_s = duct leakage factor (1-supply leakage) for supply ducts

$A_{duct,buffer}$ = total supply plus return duct area in buffer space, ft²

$A_{duct,outdoor}$ = total supply plus return duct area located outdoors, ft²

$A_{duct,n}$ = total supply plus return duct area in space n, ft²

A_{floor} = conditioned floor area of building , ft²

$A_{r,out}$ = surface area of return duct outside conditioned space ,ft²

$A_{r,buffer}$ = return duct surface area in buffer space, ft²

$A_{r,total}$ = total return duct surface area, ft²

$A_{r,attic}$ = return duct area in attic , ft²

$A_{r,base}$ = return duct area in basement , ft²

$A_{r,crawl}$ = return duct area in crawlspace, ft²

$A_{r,gar}$ = return duct area inside garage, ft²

$A_{s,out}$ = surface area of supply duct outside conditioned space,ft²

$A_{s,buffer}$ = supply duct surface area in buffer space, ft²

$A_{s,total}$ = total supply duct surface area, ft²

$A_{s,attic}$ = supply duct area in attic , ft²

$A_{s,base}$ = supply duct area in basement , ft²

$A_{s,crawl}$ = supply duct area in crawlspace,ft²

$A_{s,gar}$ = supply duct area inside garage, ft²

$A_{s,in}$ = supply duct area inside conditioned space, ft²

A_{walls} = area of buffer space exterior walls, ft²

A_{roof} = area of buffer space roof, ft²

B_r = conduction fraction for return

B_s = conduction fraction for supply

C_p = specific heat of air = 0.24 Btu/(lb·°F)

C_{DT}, C_0, C_R, C_L regression coefficients for hourly model

DE = delivery effectiveness

DE_{design} = design delivery effectiveness

$DE_{seasonal}$ = seasonal delivery effectiveness

E_{equip} = rate of energy exchanged between equipment and delivery system, Btu/hour

E_{hr} = hourly HVAC system energy input (kW for electricity, therms for gas)

$F_{cycloss}$ = cyclic loss factor

F_{equip} = load factor for equipment

~~F_{flow} = load factor for fan flow effect on equipment efficiency~~

F_{leak} = fraction of system fan flow that leaks out of supply or return ducts

F_{load} = load factor for delivery system

F_{recov} = thermal loss recovery factor

F_{regain} = thermal regain factor

h_o = outside roof surface convection coefficient, = 3.4 Btu/hr ft²°F

I_{hor} = global solar radiation on horizontal surface, Btu/hr ft²

K_r = return duct surface area coefficient

K_s = supply duct surface area coefficient

N_{story} = number of stories of the building

P_{sp} = pressure difference between supply plenum and conditioned space [Pa]

P_{test} = test pressure for duct leakage [Pa]

Q_{buffer} = buffer space infiltration rate, cfm

~~Q_e = Flow through air handler fan at operating conditions, cfm~~
~~Flow through air handler at 400 cfm/rated ton with rated tons defined by unit scheduled capacity at the conditions the unit's ARI rating standard from Section 112 of the Standard. Airflow through heating only furnaces shall be based on a 21.7 cfm/kBtuh rated output capacity.~~

Q_{total,25} = total duct leakage at 25 Pascal, cfm

R_r = thermal resistance of return duct, h ft² °F/Btu

R_s = thermal resistance of supply duct, h ft² °F/Btu

T_{amb,cool} = cooling season ambient temperature, °F

T_{amb,heat} = heating season ambient temperature, °F

T_{amb,r} = ambient temperature for return-, °F

T_{amb,s} = ambient temperature for supply-, °F

~~T_{attic} = attic air temperature, °F~~

~~T_{base} = return duct temperature in basement, °F~~

~~T_{crawl} = return duct temperature in crawlspace, °F~~

~~T_{design} = outdoor air design temperature, °F~~

~~T_{ground} = ground temperature, °F~~

~~T_{gar} = temperature of garage air, °F~~

T_{in} = temperature of indoor air, °F

~~T_{rp} = return plenum air temperature, °F~~

~~T_{seasonal} = outdoor air seasonal temperature, °F~~

T_{solar} = sol-air temperature, °F

T_{sp} = supply plenum air temperature-, °F

UA_c = UA value for the interface between the conditioned space and the buffer space, Btu/°F

UA_{walls} = UA value for the buffer space exterior walls, Btu/°F

UA_{roof} = UA value for the buffer space exterior roof, Btu/°F

UA_c = UA value for the interface between the conditioned space and the buffer space, Btu/°F

ZLC_c = zone loss coefficient for the interface between the conditioned space and the buffer space, Btu/°F

ZLC_{total} = sum of all the zone loss coefficients for the buffer space , Btu/°F

α = solar absorptivity of roof, = 0.70 for standard roof; 0.45 for cool roof, 0.0 for ducts located outdoors

ΔT_e = temperature rise across heat exchanger-, °F

ΔT_r = temperature difference between indoors and the ambient for the return-, °F

ΔT_s = temperature difference between indoors and the ambient for the supply, °F

ΔT_{sky} = reduction of sol-air temperature due to sky radiation, = 6.5°F for standard roof and cool roof, 0.0°F for ducts located outdoors, °F.

ΔT_{sol,hr} = hourly difference between sol-air and indoor temperatures, °F

ΔT_{sol,season} = energy weighted seasonal average difference between sol-air and indoor temperatures, °F

η_{adj,hr} = hourly distribution efficiency adjustment factor

η_{dist,seasonal} = seasonal distribution system efficiency

η_{dist,hr} = hourly distribution system efficiency

ρ = density of air = 0.075, lb/ft³

NG.4 Air Distribution Diagnostic Measurement and Default Assumptions

NG.4.1 Instrumentation Specifications

The instrumentation for the air distribution diagnostic measurements shall conform to the following specifications:

NG.4.1.1 Pressure Measurements

All pressure measurements shall be measured with measurement systems (i.e. sensor plus data acquisition system) having an accuracy of ± 0.2 Pa. All pressure measurements within the duct system shall be made with static pressure probes.

NG.4.1.2 Fan Flow Measurements

~~All measurements of distribution fan flows shall be made with measurement systems (i.e. sensor plus data acquisition system) having an accuracy of $\pm 5\%$ reading or ± 5 cfm whichever is greater.~~

NG.4.1.23 Duct Leakage Measurements

The measurement of air flows during duct leakage testing shall have an accuracy of $\pm 3\%$ of measured flow using digital gauges.

All instrumentation used for ~~fan flow and~~ duct leakage diagnostic measurements shall be calibrated according to the manufacturer's calibration procedure to conform to the above accuracy requirement. All testers performing diagnostic tests shall obtain evidence from the manufacturer that the equipment meets the accuracy specifications. The evidence shall include equipment model, serial number, the name and signature of the person of the test laboratory verifying the accuracy, and the instrument accuracy. All diagnostic testing equipment is subject to re-calibration when the period of the manufacturer's guaranteed accuracy expires.

NG.4.2 Apparatus

NG.4.2.1 Duct Leakage Pressurization

The apparatus for fan pressurization duct leakage measurements shall consist of a duct pressurization and flow measurement device meeting the specifications in Section NG.4.1.23.

NG.4.3 Procedure

The following sections identify input values for building and HVAC system (including ducts) using either default or diagnostic information.

NG.4.3.1 Building Information and Defaults

The calculation procedure for determining air distribution efficiencies requires the following building information:

1. climate zone for the building,
2. conditioned floor area, ~~and~~
3. number of stories,
4. areas and U-values of surfaces enclosing space between the roof and a ceiling, and
5. surface area of ductwork if ducts are located outdoors or in multiple spaces.

NG4.3.1.1 Default Input

Using default values rather than diagnostic procedures produce relatively low air distribution-system efficiencies.

Default values shall be obtained from following sections:

1. the location of the duct system in Section NG.4.3.4,
2. the surface area and insulation level of the ducts in Sections NG.4.3.3, NG.4.3.4 and NG.4.3.6,
3. the system fan flow in Section NG.4.3.7, and
4. the leakage of the duct system in Section NG.4.3.8.

NG.4.3.2 Diagnostic Input

Diagnostic inputs are used for the calculation of improved duct efficiency. The diagnostics include observation of various duct characteristics and measurement of duct leakage and system fan flows as described in Sections NG.4.3.5 through NG.4.3.8. These observations and measurements replace those assumed as default values.

The diagnostic procedures include:

- Measurement of total duct system leakage as described in Section NG.4.3.8.
- Measurement of duct surface area if ducts are located outdoors or in multiple spaces as described in Section 4.3.3.
- Observe Observation of the insulation level for the supply (R_s) and return (R_r) ducts outside the conditioned space as described in Section NG.4.3.6.
- Observation of the presence of a cool roof.
- Observation of the presence of an outdoor air economizer.

NG.4.3.3 Duct Surface Area

The supply-side and return-side duct surface areas shall be calculated separately. If the supply or return duct is located in more than one zonospace, the area of that duct in each zonospace shall may shall be calculated separately. The duct surface area shall be determined using one of the following methods.

NG.4.3.3.1 Default Duct Surface Area

The default duct surface area for supply and return shall be calculated as follows:

For supplies:

$$\text{Equation NG-1} \quad A_{s,\text{total}} = K_s A_{\text{floor}}$$

Where K_s (supply duct surface area coefficient) shall be 4-0.25 for systems serving the top one story buildings only, 0.125 for systems serving the top story plus one other two-story buildings, and 0.0833 for systems serving three or more stories-story buildings.

For returns:

$$\text{Equation NG-2} \quad A_{r,\text{total}} = K_r A_{\text{floor}}$$

Where K_r (return duct surface area coefficient) shall be 0.105 for systems serving the top story only, 0.125 for systems serving the top story plus one other, and 0.08 for systems serving three or more stories for one story building and 0.1 for two or more stories.

If ducts are located outdoors, the outdoor duct surface area shall be calculated from the duct layout on the plans using measured duct lengths and nominal inside diameters (for round ducts) or inside perimeters (for rectangular ducts) of each outdoor duct run in the building that is within the scope of the calculation procedure. When using the default duct area, outdoor supply duct surface area shall be less than or equal to the default supply duct surface area; outdoor return duct surface area shall be less than or equal to the default return duct surface area.

The surface area of ducts located in the buffer space between ceilings and roofs shall be calculated from:

Equation NG-3

$$A_{s,buffer} = A_{s,total} - A_{s,outdoors}$$

Equation NG-4

$$A_{r,buffer} = A_{r,total} - A_{r,outdoors}$$

NG4.3.3.2 Measured Duct Surface Area

Measured duct surface areas shall be used when the outdoor duct surface area measured from the plans is greater than default duct surface area for either supply ducts or return ducts. If a duct system passes through multiple spaces that have different ambient temperature conditions as specified in Section 4.3.5, the duct surface area shall be measured for each space individually. The duct surface area shall be calculated from measured duct lengths and nominal inside diameters (for round ducts) or inside perimeters (for rectangular ducts) of each duct run located in buffer spaces or outdoors.

NG.4.3.4 Duct Location

Duct systems covered by this procedure are those specified in the Standards § 144(k)3.

Ducts shall be considered to be installed in spaces between ceilings and roofs or building exteriors if more than 50 lineal feet of duct or 75 percent of the duct surface area is located in a space between an insulated ceiling and the roof, and that space is either a) vented to the outdoors, and/or b) insulated from the indoors.

NG.4.3.5 Climate and Duct Ambient Conditions for Ducts in the Space Between an Insulated Ceiling and the Roof

Duct ambient temperatures for both heating and cooling shall be obtained from Tables NG-1a to NG-1e. The duct ambient temperatures for the cool roofs from Table NG-1c shall be used for ducts located in unconditioned spaces other than attics and outside. Indoor dry-bulb (T_{in}) temperature for cooling is 78°F. The indoor dry-bulb temperature for heating is 70°F.

Table NG-1a Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Ceiling Insulation, No roof insulation, Non-vented Attic

TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.

Climate zone	Duct Ambient Temperature for Heating, <u>T_{amb., heat}</u>	Duct Ambient Temperature for Cooling, <u>T_{amb., cool}</u>			
1	<u>47.352.0</u>	<u>78.060.0</u>	<u>72.4</u>	<u>81.4</u>	<u>75.3</u>
2	<u>41.848.0</u>	<u>93.287.0</u>	<u>84.8</u>	<u>97.1</u>	<u>88.2</u>
3	<u>47.855.0</u>	<u>83.580.0</u>	<u>77.1</u>	<u>86.6</u>	<u>79.8</u>
4	<u>43.953.0</u>	<u>89.179.0</u>	<u>82.0</u>	<u>92.0</u>	<u>84.5</u>
5	<u>46.249.0</u>	<u>83.874.0</u>	<u>77.5</u>	<u>86.0</u>	<u>79.3</u>
6	<u>50.857.0</u>	<u>85.481.0</u>	<u>79.4</u>	<u>87.3</u>	<u>81.1</u>
7	<u>49.362.0</u>	<u>86.874.0</u>	<u>80.7</u>	<u>88.7</u>	<u>82.3</u>
8	<u>47.358.0</u>	<u>91.380.0</u>	<u>84.2</u>	<u>93.1</u>	<u>85.9</u>
9	<u>48.753.0</u>	<u>92.587.0</u>	<u>85.4</u>	<u>94.4</u>	<u>87.2</u>
10	<u>45.753.0</u>	<u>95.991.0</u>	<u>87.9</u>	<u>98.2</u>	<u>90.0</u>
11	<u>43.948.0</u>	<u>95.595.0</u>	<u>88.1</u>	<u>98.4</u>	<u>90.5</u>
12	<u>44.250.0</u>	<u>94.391.0</u>	<u>86.7</u>	<u>97.3</u>	<u>89.3</u>
13	<u>43.348.0</u>	<u>100.992.0</u>	<u>92.5</u>	<u>103.6</u>	<u>94.9</u>
14	<u>37.239.0</u>	<u>99.099.0</u>	<u>90.6</u>	<u>102.7</u>	<u>93.8</u>
15	<u>47.250.0</u>	<u>102.9402.</u>	<u>95.8</u>	<u>104.3</u>	<u>97.1</u>
16	<u>37.932.0</u>	<u>92.080.0</u>	<u>83.8</u>	<u>96.3</u>	<u>87.5</u>

Table NG-1b Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Ceiling Insulation, No roof insulation, Vented Attic

TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.

<u>Climate zone</u>	<u>Duct Ambient Temperature for Heating, T_{amb_heat}</u>	<u>Duct Ambient Temperature for Cooling, T_{amb_cool}</u>			
<u>1</u>	<u>48.6</u>	<u>73.7</u>	<u>69.8</u>	<u>76.7</u>	<u>72.5</u>
<u>2</u>	<u>43.4</u>	<u>87.9</u>	<u>82.2</u>	<u>91.7</u>	<u>85.7</u>
<u>3</u>	<u>48.9</u>	<u>79.2</u>	<u>74.8</u>	<u>82.1</u>	<u>77.4</u>
<u>4</u>	<u>45.1</u>	<u>84.4</u>	<u>79.5</u>	<u>87.1</u>	<u>81.9</u>
<u>5</u>	<u>47.7</u>	<u>79.7</u>	<u>75.4</u>	<u>81.9</u>	<u>77.3</u>
<u>6</u>	<u>51.8</u>	<u>81.0</u>	<u>76.8</u>	<u>81.0</u>	<u>78.5</u>
<u>7</u>	<u>50.6</u>	<u>82.4</u>	<u>78.1</u>	<u>84.1</u>	<u>79.7</u>
<u>8</u>	<u>48.7</u>	<u>86.4</u>	<u>81.5</u>	<u>88.2</u>	<u>83.2</u>
<u>9</u>	<u>49.3</u>	<u>88.4</u>	<u>83.4</u>	<u>90.2</u>	<u>85.1</u>
<u>10</u>	<u>47.1</u>	<u>90.9</u>	<u>85.4</u>	<u>93.2</u>	<u>87.6</u>
<u>11</u>	<u>44.8</u>	<u>90.9</u>	<u>85.8</u>	<u>93.7</u>	<u>88.3</u>
<u>12</u>	<u>45.2</u>	<u>89.6</u>	<u>84.4</u>	<u>92.5</u>	<u>87.0</u>
<u>13</u>	<u>44.5</u>	<u>95.1</u>	<u>89.3</u>	<u>97.7</u>	<u>91.7</u>
<u>14</u>	<u>38.6</u>	<u>93.7</u>	<u>87.8</u>	<u>97.2</u>	<u>91.0</u>
<u>15</u>	<u>48.4</u>	<u>98.6</u>	<u>93.7</u>	<u>100.1</u>	<u>95.1</u>
<u>16</u>	<u>38.7</u>	<u>86.9</u>	<u>81.1</u>	<u>91.1</u>	<u>84.9</u>

Table NG-1c Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Ceiling Insulation, Roof insulation, Non-vented Attic

TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.

<u>Climate zone</u>	<u>Duct Ambient Temperature for Heating, T_{amb_heat}</u>	<u>Duct Ambient Temperature for Cooling, T_{amb_cool}</u>			
<u>1</u>	<u>56.4</u>	<u>77.6</u>	<u>74.8</u>	<u>79.9</u>	<u>76.9</u>
<u>2</u>	<u>54.8</u>	<u>86.9</u>	<u>82.8</u>	<u>89.7</u>	<u>85.4</u>
<u>3</u>	<u>56.4</u>	<u>81.1</u>	<u>77.9</u>	<u>83.3</u>	<u>79.9</u>
<u>4</u>	<u>54.6</u>	<u>84.9</u>	<u>81.3</u>	<u>87.0</u>	<u>83.3</u>
<u>5</u>	<u>56.6</u>	<u>81.3</u>	<u>78.2</u>	<u>82.9</u>	<u>79.6</u>
<u>6</u>	<u>57.1</u>	<u>83.9</u>	<u>80.1</u>	<u>85.5</u>	<u>81.6</u>
<u>7</u>	<u>55.7</u>	<u>84.9</u>	<u>81.1</u>	<u>86.5</u>	<u>82.5</u>
<u>8</u>	<u>54.5</u>	<u>88.0</u>	<u>83.6</u>	<u>89.5</u>	<u>85.0</u>
<u>9</u>	<u>59.9</u>	<u>83.6</u>	<u>81.6</u>	<u>84.2</u>	<u>82.1</u>
<u>10</u>	<u>55.9</u>	<u>89.4</u>	<u>85.6</u>	<u>91.2</u>	<u>87.2</u>
<u>11</u>	<u>53.1</u>	<u>89.7</u>	<u>86.1</u>	<u>91.8</u>	<u>87.9</u>
<u>12</u>	<u>53.7</u>	<u>88.7</u>	<u>84.8</u>	<u>90.9</u>	<u>86.8</u>
<u>13</u>	<u>53.6</u>	<u>93.1</u>	<u>89.0</u>	<u>95.2</u>	<u>90.9</u>
<u>14</u>	<u>48.7</u>	<u>91.9</u>	<u>87.6</u>	<u>94.7</u>	<u>90.1</u>
<u>15</u>	<u>56.1</u>	<u>95.9</u>	<u>92.3</u>	<u>97.0</u>	<u>93.4</u>
<u>16</u>	<u>48.5</u>	<u>86.6</u>	<u>82.4</u>	<u>89.6</u>	<u>85.1</u>

Table NG-1d Default Assumptions for Duct Ceiling/Roof Space Ambient Temperature, Roof Insulation, No Ceiling Insulation, Non-vented Attic

TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.

<u>Climate zone</u>	<u>Duct Ambient Temperature for Heating, T_{amb_heat}</u>	<u>Duct Ambient Temperature for Cooling, T_{amb_cool}</u>			
<u>1</u>	<u>59.8</u>	<u>78.5</u>	<u>77.3</u>	<u>79.3</u>	<u>78.0</u>
<u>2</u>	<u>59.0</u>	<u>82.5</u>	<u>80.8</u>	<u>83.5</u>	<u>81.6</u>
<u>3</u>	<u>60.1</u>	<u>80.0</u>	<u>78.6</u>	<u>80.7</u>	<u>79.3</u>
<u>4</u>	<u>58.9</u>	<u>81.6</u>	<u>80.1</u>	<u>82.3</u>	<u>80.7</u>
<u>5</u>	<u>60.0</u>	<u>80.0</u>	<u>78.6</u>	<u>80.6</u>	<u>79.1</u>
<u>6</u>	<u>60.4</u>	<u>81.2</u>	<u>79.5</u>	<u>81.8</u>	<u>80.0</u>
<u>7</u>	<u>59.7</u>	<u>81.7</u>	<u>79.9</u>	<u>82.2</u>	<u>80.5</u>
<u>8</u>	<u>58.8</u>	<u>83.1</u>	<u>81.1</u>	<u>83.7</u>	<u>81.7</u>
<u>9</u>	<u>59.9</u>	<u>83.6</u>	<u>81.6</u>	<u>84.2</u>	<u>82.1</u>
<u>10</u>	<u>58.5</u>	<u>83.4</u>	<u>81.8</u>	<u>84.0</u>	<u>82.3</u>
<u>11</u>	<u>58.5</u>	<u>83.7</u>	<u>82.1</u>	<u>84.3</u>	<u>82.7</u>
<u>12</u>	<u>58.3</u>	<u>83.2</u>	<u>81.6</u>	<u>83.8</u>	<u>82.1</u>
<u>13</u>	<u>58.3</u>	<u>85.1</u>	<u>83.3</u>	<u>85.7</u>	<u>83.9</u>
<u>14</u>	<u>54.5</u>	<u>84.5</u>	<u>82.8</u>	<u>85.4</u>	<u>83.5</u>
<u>15</u>	<u>58.6</u>	<u>86.1</u>	<u>84.6</u>	<u>86.5</u>	<u>84.9</u>
<u>16</u>	<u>55.6</u>	<u>82.4</u>	<u>80.7</u>	<u>83.4</u>	<u>81.5</u>

Table NG-1e Default Assumptions for Duct Ambient Temperature, Ducts Located Outdoors**TABLES ARE NOT YET POPULATED AS RESULTS ARE STILL BEING REVIEWED.**

<u>Climate zone</u>	<u>Duct Ambient Temperature for Heating, $T_{amb, heat}$</u>	<u>Duct Ambient Temperature for Cooling, $T_{amb, cool}$</u> Without economizer	<u>Duct Ambient Temperature for Cooling, $T_{amb, cool}$</u> With economizer
<u>1</u>	<u>47.7</u>	<u>62.7</u>	<u>65.4</u>
<u>2</u>	<u>42.5</u>	<u>76.0</u>	<u>79.7</u>
<u>3</u>	<u>47.6</u>	<u>68.5</u>	<u>71.3</u>
<u>4</u>	<u>43.5</u>	<u>73.3</u>	<u>75.8</u>
<u>5</u>	<u>47.1</u>	<u>69.5</u>	<u>71.7</u>
<u>6</u>	<u>50.7</u>	<u>70.0</u>	<u>71.8</u>
<u>7</u>	<u>50.2</u>	<u>71.6</u>	<u>73.2</u>
<u>8</u>	<u>48.3</u>	<u>74.6</u>	<u>76.4</u>
<u>9</u>	<u>47.0</u>	<u>78.1</u>	<u>80.0</u>
<u>10</u>	<u>46.7</u>	<u>79.9</u>	<u>82.1</u>
<u>11</u>	<u>42.8</u>	<u>81.3</u>	<u>83.8</u>
<u>12</u>	<u>43.4</u>	<u>79.4</u>	<u>82.0</u>
<u>13</u>	<u>43.0</u>	<u>83.2</u>	<u>85.4</u>
<u>14</u>	<u>36.4</u>	<u>81.8</u>	<u>85.1</u>
<u>15</u>	<u>48.1</u>	<u>90.7</u>	<u>92.2</u>
<u>16</u>	<u>35.7</u>	<u>73.5</u>	<u>78.1</u>

NG.4.3.6 Duct Wall Thermal Resistance**NG.4.3.6.1 Default Duct Insulation R value**

Default duct wall thermal resistance for new buildings is R-8.04.2, the mandatory requirement for ducts installed in newly constructed buildings, additions and new or replacement ducts installed in existing buildings. Default duct wall thermal resistance for existing ducts in existing buildings is R-4.2. An air film resistance of 0.7 [h ft² °F/BTU] shall be added to the duct insulation R value to account for external and internal film resistance.

NG.4.3.6.2 Diagnostic Duct Wall Thermal Resistance

Duct wall thermal resistance shall be determined from the manufacturer's specification observed during diagnostic inspection. If ducts with multiple R values are installed, the lowest duct R value shall be used. If a duct with a higher R value than 8.04.2 is installed, the R-value shall be clearly stated on the building plans and a visual inspection of the ducts must be performed to verify the insulation values. In case the space on top of the duct boot is limited and can not be inspected, the insulation R value within two feet of the boot to which the duct is connected may be excluded from the determination of the overall system R value.

NG.4.3.7 System Total Fan Flow**NG.4.3.7.1 Default Fan Flow**

The default cooling total fan flow with for an air conditioner and for heating with or a heat pump for all climate zones shall be calculated as follows:

$$Q_e = 1.25 A_{floor} \quad (4.3)$$

equal to 400 cfm/rated ton with rated tons defined by unit scheduled capacity at the conditions the unit's ARI rating standard from Section 112 of the Standard. Airflow through heating only furnaces shall be based on 21.7 cfm/kBtuh rated output capacity.

NG.4.3.8 Duct Leakage

NG.4.3.8.1 Duct Leakage Factor for Delivery Effectiveness Calculations

Default duct leakage factors for the Proposed Design shall be obtained from Table NG-2, using the "not Tested" values.

Duct leakage factors for the Standard Design shall be obtained from Table NG-2, using the appropriate "Tested" value.

Duct leakage factors shown in Table NG-2 shall be used in calculations of delivery effectiveness.

Table NG-2 Duct Leakage Factors

	Duct Leakage Diagnostic Test Performed using Section 4.3.8.2 Procedures	as = ar =
<u>Untested duct systems in buildings built prior to June 1, 2004</u>	Not tested	<u>0.86</u>
<u>Untested duct systems in buildings built after June 2, 2004</u>	Not tested	<u>0.8289</u>
<u>Duct systems in buildings of all ages, System tested after HVAC system completion</u>	(Q _{total} /25) Total leakage is less than 0.06 Q _e	<u>0.96</u>
<u>Sealed and tested duct systems in existing buildings, System tested after HVAC equipment and/or duct installation</u>		<u>0.915</u>
<u>Sealed and tested duct systems in new buildings duct systems, System tested after HVAC system installation</u>	(Q _{total} /25) Total leakage is less than 0.06 Q _e	<u>0.96</u>

NG.4.3.8.2 Diagnostic Duct Leakage

~~Diagnostic duct leakage measurement is used to quantify total leakage for the calculation of air distribution efficiency. To obtain the improved duct efficiency for sealing the duct system, a diagnostic leakage test as described in section NG.4.3.8.2.1 or NG.4.3.8.2.2 must be performed.~~

Diagnostic duct leakage measurement is used by installers and raters to verify that total leakage meets the criteria for any sealed duct system specified in the compliance documents. Table NG-3 shows the leakage criteria and test procedures that may be used to demonstrate compliance. In addition to the minimum tests shown, existing duct systems may be tested to show they comply with the criteria for new duct systems.

Table NG-3 Duct Leakage Tests

<u>Case</u>	<u>User and Application</u>	<u>Leakage criteria, % of total fan flow</u>	<u>Procedure</u>
<u>Sealed and tested new duct systems</u>	<u>Installer Testing HERS Rater Testing</u>	<u>6%</u>	<u>NG 4.3.8.2.1</u>
<u>Sealed and tested altered existing duct systems</u>	<u>Installer Testing HERS Rater Testing</u>	<u>15% Total Duct Leakage</u>	<u>NG 4.3.8.2.1</u>
	<u>Installer Testing and Inspection HERS Rater Testing and Verification</u>	<u>60% Reduction in Leakage and Visual Inspection</u>	<u>NG 4.3.8.2.2 RC4.3.6 and RC4.3.7</u>
	<u>Installer Testing and Inspection HERS Rater Testing and Verification</u>	<u>Fails Leakage Test but All Accessible Ducts are Sealed And Visual Inspection</u>	<u>NG 4.3.8.2.3 RC4.3.6 and RC4.3.7</u>

NG.4.3.8.2.1 Diagnostic Total Duct Leakage Test from Fan Pressurization of Ducts

The objective of this procedure is for an installer to determine or a rater to verify the total leakage of a new or altered duct system. The total duct leakage shall be determined by pressurizing both the supply and return ducts to 25 Pascals with all ceiling diffusers/grilles and HVAC equipment installed. When existing ducts are to be altered, this test shall be performed prior to and after duct sealing. The following procedure shall be used for the fan pressurization tests:

1. Verify that the air handler, supply and return plenums and all the connectors, transition pieces, duct boots and registers are installed. The entire system shall be included in the test.
2. For newly installed or altered ducts, verify that cloth backed rubber adhesive duct tape has not been used.
3. Seal all the supply and return registers, except for one return register or the system fan access. Verify that all outside air dampers and /or economizers are sealed prior to pressurizing the system.
2. Attach the fan flowmeter device to the duct system at the unsealed register or access door.
3. Install a static pressure probe at a supply.
4. Adjust the fan flowmeter to produce a 25 Pascal (0.1 in water) pressure difference between the supply duct and the outside or the building space with the entry door open to the outside.
5. Record the flow through the flowmeter ($Q_{total,25}$) - this is the total duct leakage flow at 25 Pascals.
6. Divide the leakage flow by the total fan flow and convert to a percentage. If the leakage flow percentage is less than 6% for new duct systems or less than 15% for altered duct systems, the system passes.

Duct systems that have passed this total leakage test will be sampled by a HERS rater to show compliance.

When the diagnostic leakage test is performed and the measured total duct leakage is less than 6% of the total fan flow, the duct leakage factor shall be 0.96 as shown in Table NG-2.

NG.4.3.8.2.2 Diagnostic Duct Leakage Using An Aerosol Sealant Closure System

Same procedure as for other closure systems.

3

NG 4.3.8.2.2 Leakage Improvement from Fan Pressurization of Ducts

For altered existing duct systems which have a higher leakage percentage than the Total Duct leakage criteria in Section NG 4.3.8.2.1, the objective of this test is to show that the original leakage is reduced through duct sealing as specified in Table NG-3. The following procedure shall be used:

1. Use the procedure in NG 4.3.8.2.1 to measure the leakage before commencing duct sealing.
2. After sealing is complete use the same procedure to measure the leakage after duct sealing.

3. Subtract the sealed leakage from the original leakage and divide the remainder by the original leakage. If the leakage reduction is 60% or greater of the original leakage, the system passes.

4. Complete the Visual Inspection specified in NG 4.3.8.2.4.

Duct systems that have passed this leakage reduction test and the visual inspection test will be sampled by a HERS rater to show compliance.

NG 4.3.8.2.3 Sealing of All Accessible Leaks

For altered existing duct systems that do not pass the Total Leakage test (NG 4.3.8.2.1), the objective of this test is to show that all accessible leaks are sealed and that excessively damaged ducts have been replaced. The following procedure shall be used:

1. Complete each of the leakage tests

1. Complete the Visual Inspection as specified in NG 4.3.8.2.4.

All duct systems that could not pass either the total leakage test or the leakage improvement test will be tested by a HERS rater to show compliance. This is a sampling rate of 100%.

NG 4.3.8.2.4 Visual Inspection of Accessible Duct Sealing

For altered existing duct systems that fail to be sealed to 15% of total fan flow, the objective of this inspection is to confirm that all accessible leaks have been sealed and that excessively damaged ducts have been replaced. The following procedure shall be used:

1. Visually inspect to verify that the following locations have been sealed:

- Connections to plenums and other connections to the forced air unit
- Refrigerant line and other penetrations into the forced air unit
- Air handler door panel (do not use permanent sealing material, metal tape is acceptable)
- Register boots sealed to surrounding material
- Connections between lengths of duct, as well as connections to takeoffs, wyes, tees, and splitter boxes.

2. Visually inspect to verify that portions of the duct system that are excessively damaged have been replaced. Ducts that are considered to be excessively damaged are:

- Flex ducts with the vapor barrier split or cracked with a total linear split or crack length greater than 12 inches
- Crushed ducts where cross-sectional area is reduced by 30% or more
- Metal ducts with rust or corrosion resulting in leaks greater than 2 inches in any dimension
- Ducts that have been subject to animal infestation resulting in leaks greater than 2 inches in any dimension

NG 4.3.8.4 Labeling requirements for tested systems

A sticker shall be affixed to the exterior surface of the air handler access door with the following text in 14 point font:

"The leakage of the air distribution ducts was found to be CFM @ 25 Pascals or % of total fan flow.

This system (check one):

Has a leakage rate that is equal to or lower than the prescriptive requirement of 6% leakage for new duct systems or 15% leakage for alterations to existing systems. It meets the prescriptive requirements of California Title 24 Energy Efficiency Standards.

p Has a leakage rate higher than 6% leakage for new duct systems or 15% leakage for altered existing systems. It does NOT meet the meet or exceed the prescriptive requirements of the Title 24 standards. However, all accessible ducts were sealed.

Signed: _____

Print name: _____

Print Company Name: _____

Print Contractor License No: _____

Print Contractor Phone No: _____

Do not remove sticker"

NG.4.4 Delivery Effectiveness (DE) Calculations

Seasonal delivery effectiveness shall be calculated using the seasonal design temperatures from Table NG-1.

NG.4.4.1 Calculation of Duct Zone Temperatures

The temperatures of the duct zones outside the conditioned space are determined in Section NG.4.3.5 for seasonal conditions for both heating and cooling.

For heating:

Equation NG-5 $T_{amb,s} = T_{amb,r} = T_{amb,heat}$

For cooling:

Equation NG-6 $T_{amb,s} = T_{amb,r} = T_{amb,cool}$

Where

$T_{amb,heat}$ and $T_{amb,cool}$ are determined from values in Table NG.4.1.

If the ducts are not all in the same location, the duct ambient temperature for use in the delivery effectiveness and distribution system efficiency calculations shall be determined using an area weighted average of the duct ambient temperatures for heating and cooling:

$$\text{Equation NG-7} \quad T_{amb,heat} = \frac{A_{duct,buffer} \times T_{amb\ heat,buffer} + A_{duct,outdoors} \times T_{amb\ heat,outdoors}}{A_{duct,buffer} + A_{duct,outdoors}}$$

$$\text{Equation NG-8} \quad T_{amb,cool} = \frac{A_{duct,buffer} \times T_{amb\ cool,buffer} + A_{duct,outdoors} \times T_{amb\ cool,outdoors}}{A_{duct,buffer} + A_{duct,outdoors}}$$

where the buffer space ambient temperature shall correspond to the location yielding the lowest seasonal delivery effectiveness.

Alternatively, the duct ambient temperature for use in the delivery effectiveness and distribution system efficiency calculations can be determined using an area weighted average of the duct zone temperatures for heating and cooling in all spaces:

$$\text{Equation NG-9} \quad T_{amb,heat} = \frac{A_{duct,1} \times T_{amb\ heat,1} + A_{duct,2} \times T_{amb\ heat,2} + \dots + A_n \times T_{amb\ heat,n}}{A_{duct,1} + A_{duct,2} + \dots + A_{duct,n}}$$

$$\text{Equation NG-10} \quad T_{\text{amb,cool}} = \frac{A_{\text{duct,1}} \times T_{\text{amb cool,1}} + A_{\text{duct,2}} \times T_{\text{amb cool,2}} + \dots + A_n \times T_{\text{amb cool,n}}}{A_{\text{duct,1}} + A_{\text{duct,2}} + \dots + A_{\text{duct,n}}}$$

NG.4.4.2 Seasonal Delivery Effectiveness (DE)

The supply and return conduction fractions, B_s and B_r , shall be calculated as follows:

$$\text{Equation NG-11} \quad B_s = \exp\left(\frac{-A_{s,\text{out}}}{1.08 Q_e R_s}\right)$$

$$\text{Equation NG-12} \quad B_r = \exp\left(\frac{-A_{r,\text{out}}}{1.08 Q_e R_r}\right)$$

The temperature difference across the heat exchanger in the following equation is used:

for heating:

$$\text{Equation NG-13} \quad \Delta T_e = 55 \quad (4.8)$$

for cooling:

$$\text{Equation NG-14} \quad \Delta T_e = -20 \quad (4.9)$$

The temperature difference between the building conditioned space and the ambient temperature surrounding the supply, ΔT_s , and return, ΔT_r , shall be calculated using the indoor and the duct ambient temperatures.

$$\text{Equation NG-15} \quad \Delta T_s = T_{\text{in}} - T_{\text{amb,s}} \quad (4.10)$$

$$\text{Equation NG-16} \quad \Delta T_r = T_{\text{in}} - T_{\text{amb,r}} \quad (4.11)$$

The seasonal delivery effectiveness for heating or cooling systems shall be calculated using:

$$\text{Equation NG-17} \quad DE_{\text{seasonal}} = a_s B_s - a_s B_s (1 - B_r) \frac{\Delta T_r}{\Delta T_e} - a_s (1 - B_s) \frac{\Delta T_s}{\Delta T_e}$$

NG.4.5 Seasonal Distribution System Efficiency

Seasonal distribution system efficiency shall be calculated using delivery effectiveness, equipment, load, and recovery factors calculated for seasonal conditions.

NG.4.5.1 Equipment Efficiency Factor (F_{equip})

F_{equip} is 1.

NG.4.5.2 Thermal Regain (F_{regain})

The reduction in building load due to regain of duct losses shall be calculated using the thermal regain factor.
The default thermal regain factors are provided in Table NG-3.

Table NG-3 Thermal Regain Factors

Supply Duct Location	Thermal Regain Factor [F _{regain}]
Ceiling/Roof Space	0.10

Equation NG-18
$$F_{\text{regain}} = \frac{ZLC_c}{ZLC_{\text{total}}} \quad \text{where:}$$

Equation NG-19
$$ZLC_c = UA_c + 60Q_e(1 - a_r)\rho Cp$$

Equation NG-20
$$ZLC_{\text{total}} = \sum_{\text{bufferspacesurfaces}} UA + Q_{\text{buffer}}\rho Cp + 60Q_e(1 - a_r)\rho Cp$$

Equation NG-21
$$UA_{\text{bufferspacesurfaces}} = UA_c + UA_{\text{walls}} + UA_{\text{roof}}$$

Equation NG-22
$$Q_{\text{buffer}} = 0.038(60)A_{\text{walls}}pc_p \text{ for non-vented buffer spaces}$$

Equation NG-23
$$Q_{\text{buffer}} = 0.25(60)A_{\text{roof}}pc_p \text{ for -vented buffer spaces}$$

Thermal regain for ducts located outdoors shall be equal to 0.0. If the ducts are not all in the same location, the regain shall be determined using an area weighted average of the regain for heating and cooling:

Equation NG-24

$$F_{\text{regain}} = \frac{A_{\text{duct},1} \times F_{\text{regain},1} + A_{\text{duct},2} \times F_{\text{regain},2} + \dots + A_{\text{duct},n} \times F_{\text{regain},n}}{A_{\text{duct},1} + A_{\text{duct},2} + \dots + A_{\text{duct},n}}$$

NG.4.5.3 Recovery Factor (F_{recov})

The recovery factor, F_{recov}, is calculated based on the thermal regain factor, F_{regain}, and the duct losses without return leakage.

Equation NG-25
$$F_{\text{recov}} = 1 + F_{\text{regain}} \left(\frac{1 - a_s B_s + a_s B_s (1 - B_r) \frac{\Delta T_r}{\Delta T_e} + a_s (1 - B_s) \frac{\Delta T_s}{\Delta T_e}}{DE_{\text{seasonal}}} \right)$$

NG.4.5.4 Seasonal Distribution System Efficiency

The seasonal distribution system efficiency shall be calculated using the seasonal delivery effectiveness from section NG.4.4.2, the equipment efficiency factor from section NG.4.5.1, and the recovery factor from section NG.4.5.3. Note that DE_{seasonal}, F_{equip}, F_{recov} must be calculated separately for cooling and heating conditions. Distribution system efficiency shall be determined using the following equation:

Equation NG-26
$$\eta_{\text{dist,seasonal}} = 0.98 DE_{\text{seasonal}} F_{\text{equip}} F_{\text{recov}}$$

where 0.98 accounts for the energy losses from heating and cooling the duct thermal mass.

NG.4.6 Hourly Distribution System Efficiency

The hourly duct efficiency shall be calculated for each hour using the following equation:

Equation NG-27

$$\eta_{\text{dist,hr}} = \frac{\eta_{\text{dist,seasonal}}}{\eta_{\text{adj,hr}}} \quad \underline{\eta_{\text{dist,hr}} \leq 1}$$

where the hourly efficiency is calculated from the seasonal efficiency and an hourly efficiency adjustment factor. The hourly distribution efficiency shall be less than or equal to 1.0. The hourly duct efficiency adjustment factor shall be calculated from the following equation:

Equation NG-28

$$\eta_{\text{adj,hr}} = 1 + C_{\text{DT}} \times (\Delta T_{\text{sol,hr}} - \Delta T_{\text{sol,season}})$$

where the hourly efficiency adjustment factor is calculated from the difference between the hourly roof sol-air temperature and the hourly indoor temperature; the difference between the seasonal average difference between the roof sol-air temperature and the indoor temperature; and a constant derived from regression analysis.

The hourly difference between the roof sol-air temperature and the indoor temperature shall be calculated from the following equation:

Equation NG-29

$$\Delta T_{\text{sol,hr}} = T_{\text{solair,hr}} - T_{\text{in,hr}}$$

The seasonal difference between the roof sol-air temperature and the indoor temperature shall be a load-weighted average of the hourly roof sol-air temperature and the indoor temperature, and shall be calculated from the following equation:

Equation NG-30

$$\Delta T_{\text{sol,season}} = \frac{\sum_{\text{season}} (T_{\text{solair,hr}} - T_{\text{in,hr}}) E_{\text{hr}}}{\sum_{\text{season}} E_{\text{hr}}}$$

The hourly roof sol-air temperature is a function of the hourly ambient temperature, hourly horizontal solar radiation and the roof surface absorptance; and shall be calculated from the following equation:

Equation NG-31

$$T_{\text{solair,hr}} = T_{\text{amb,hr}} + \left(\frac{\alpha}{h_o} \right) I_{\text{hor,hr}} - \Delta T_{\text{sky}}$$

The hourly efficiency adjustment factor regression coefficient shall be calculated from the following equation:

Equation NG-32

$$C_{\text{DT}} = C_0 + \frac{C_R}{R_s} + C_L Q_{\text{total},25} ; \underline{C_{\text{DT,cooling}} \geq 0.0;}$$

$$\underline{C_{\text{DT,heating}} \leq 0.0}$$

where constants C_0 , C_R , and C_L shall be taken from Table NG-3 according to the season (heating or cooling), and the roof type for ducts in the buffer space (Standard or Cool roof) or duct location (if outdoors). The calculated value of C_{DT} for cooling shall be greater than or equal to zero, and the calculated value of C_{DT} for heating shall be less than or equal to zero.

NG.4.6.3 Hourly Efficiency Adjustment Regression Coefficients and Data~~TABLES ARE NOT YET POPULATED, AS RESULTS ARE STILL BEING REVIEWED.~~*Table NG-3 Coefficients*

	Cooling			Heating		
	Standard roof	Cool roof	Outdoors	Standard roof	Cool roof	Outdoors
Co	<u>0.000486</u>	<u>0.000538</u>	<u>-0.002763</u>	<u>-0.000430</u>	<u>-0.000418</u>	<u>0.000677</u>
CR	<u>0.002810</u>	<u>0.003207</u>	<u>0.008702</u>	<u>-0.003978</u>	<u>-0.003659</u>	<u>-0.002614</u>
CL	<u>0.002143</u>	<u>0.003386</u>	<u>0.031009</u>	<u>-0.012079</u>	<u>-0.011277</u>	<u>-0.012190</u>

ACM NH-2005**Appendix NH - Seasonal Energy Efficiencies of Single-Zone Non-Residential Air Distribution Systems in the Space Between an Insulated Ceiling and the Roof in California Climate Zones Test Nonresidential Air Distribution Systems**

CASE CODE	Input Assumptions for Non-Residential Duct Systems		
	Total duct Leakage, %	Supply duct R Value	Return duct R value
1001	22	4.2	4.2
1002	22	8	8
1003	8	4.2	4.2
1004	8	8	8

CASE CODE	Climate Zone 1				Climate Zone 2				
	1 Story		2 Story		1 Story		2 Story		
	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	
1001	0.750	0.810	0.779	0.812	0.737	0.674	0.767	0.702	
1002	0.793	0.813	0.810	0.814	0.783	0.717	0.800	0.734	
1003	0.820	0.866	0.852	0.869	0.811	0.744	0.843	0.775	
1004	0.868	0.869	0.886	0.871	0.861	0.792	0.880	0.810	
Climate Zone 3									
1 Story				2 Story		1 Story		2 Story	
1001	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	
1001	0.759	0.730	0.788	0.755	0.753	0.738	0.782	0.763	
1002	0.801	0.763	0.817	0.778	0.795	0.770	0.812	0.784	
1003	0.827	0.786	0.858	0.813	0.822	0.792	0.854	0.818	
1004	0.873	0.822	0.891	0.837	0.869	0.826	0.888	0.841	
Climate Zone 5									
1 Story				2 Story		1 Story		2 Story	
1001	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	
1001	0.740	0.760	0.770	0.779	0.766	0.722	0.794	0.747	
1002	0.785	0.784	0.803	0.795	0.806	0.757	0.822	0.771	
1003	0.813	0.813	0.845	0.834	0.832	0.780	0.863	0.807	
1004	0.863	0.839	0.882	0.851	0.876	0.818	0.894	0.834	
Climate Zone 7									
1 Story				2 Story		1 Story		2 Story	
1001	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	
1001	0.781	0.760	0.809	0.779	0.769	0.752	0.797	0.770	
1002	0.819	0.784	0.835	0.795	0.808	0.776	0.825	0.786	
1003	0.844	0.813	0.873	0.834	0.834	0.809	0.865	0.829	
1004	0.884	0.839	0.901	0.851	0.878	0.835	0.895	0.847	
Climate Zone 9									
1 Story				2 Story		1 Story		2 Story	
1001	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	Heating,%	Cooling,%	
1001	0.753	0.702	0.782	0.723	0.753	0.674	0.782	0.696	
1002	0.795	0.734	0.812	0.746	0.795	0.710	0.812	0.723	
1003	0.822	0.775	0.854	0.798	0.822	0.756	0.854	0.780	
1004	0.869	0.811	0.888	0.824	0.869	0.797	0.888	0.811	

CASE CODE	Climate Zone 11				Climate Zone 12			
	1 Story		2 Story		1 Story		2 Story	
	Heating, %	Cooling, %	Heating, %	Cooling, %	Heating, %	Cooling, %	Heating, %	Cooling, %
1001	0.737	0.645	0.767	0.669	0.743	0.674	0.773	0.696
1002	0.783	0.686	0.800	0.700	0.788	0.710	0.805	0.723
1003	0.811	0.737	0.843	0.762	0.815	0.756	0.848	0.780
1004	0.861	0.783	0.880	0.798	0.864	0.797	0.883	0.811
Climate Zone 13				Climate Zone 14				
	1 Story		2 Story		1 Story		2 Story	
	Heating, %	Cooling, %	Heating, %	Cooling, %	Heating, %	Cooling, %	Heating, %	Cooling, %
1001	0.737	0.667	0.767	0.689	0.709	0.617	0.740	0.642
1002	0.783	0.704	0.800	0.717	0.759	0.663	0.778	0.677
1003	0.811	0.751	0.843	0.776	0.789	0.717	0.824	0.745
1004	0.861	0.793	0.880	0.807	0.846	0.768	0.866	0.784
Climate Zone 15				Climate Zone 16				
	1 Story		2 Story		1 Story		2 Story	
	Heating, %	Cooling, %	Heating, %	Cooling, %	Heating, %	Cooling, %	Heating, %	Cooling, %
1001	0.743	0.596	0.773	0.622	0.686	0.730	0.719	0.755
1002	0.788	0.645	0.805	0.660	0.742	0.763	0.761	0.778
1003	0.815	0.703	0.848	0.731	0.773	0.786	0.809	0.813
1004	0.864	0.758	0.883	0.775	0.835	0.822	0.856	0.837

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Appendix NI - Alternate Default Fenestration Thermal Properties

Scope

This appendix applies to fenestration excepted from Section 116 (a) 2 and Section 116 (a) 3 of the Standard.

"EXCEPTION to Section 116 (a) 2: If the fenestration product is site-built fenestration in a building covered by the nonresidential standards with less than 10,000 square feet of site-built fenestration or is a skylight, the default U-factor may be the applicable U-factor as set forth in the Nonresidential ACM Manual."

"EXCEPTION to Section 116 (a) 3: If the fenestration product is site-built fenestration in a building covered by the nonresidential standards with less than 10,000 square feet of site-built fenestration or is a skylight, the default SHGC may be calculated according to Equation 116-A."

Purpose

To present alternate default U-factors and the calculation method for determining an alternate default SHGC, and to describe the responsibilities of energy consultants, designers, architects, builders, installers, and building departments when an alternate default value is used for determining compliance.

NI.1 Solar Heat Gain Coefficient

Determination of Solar Heat Gain Coefficients for Fenestration without Certified NFRC Values

This section describes the calculation method, eligibility criteria, and documentation requirements for determining the SHGC of fenestration for which there is no certified NFRC value.

Site-Assembled Fenestration Products and Field-fabricated Fenestration

This section describes the alternative calculation method for determining compliance for site-assembled and field-fabricated products similar to eligible site-built products.

Site-assembled fenestration includes both field-fabricated fenestration and fenestration whose frame is previously cut or formed by a manufacturer with the specific intention of being used with a glazing assembly to create a complete fenestration product.

Field-fabricated fenestration is a fenestration product whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut or otherwise formed with the specific intention of being used to fabricate a fenestration product.

For site-assembled and field-fabricated fenestration, use the following equation may be used to calculate the fenestration product's SHGC for fenestration that is used to determine compliance. Convert the center of glass SHGC, SHGC_c, from the manufacturer's documentation to a value for the fenestration product with framing, SHGC_{fen},

$$\text{SHGC}_{\text{fen}} = 0.08 + 0.86 \times \text{SHGC}_c$$

Where:

SHGC_{fen} is the SHGC for the fenestration including glass and frame.

SHGC_c is the SHGC for the center of glass alone, and

SHGC_{fen} is the SHGC for the fenestration including glass and frame.

Manufactured Fenestration Products

This section describes the alternative calculation method for determining compliance for manufactured products that do not have SHGC values published by the National Fenestration Rating Council (NFRC) in the NFRC Certified Products Directory.

Manufactured Fenestration Products without a SHGC certified to the NFRC are similar to those that have an SHGC certified to NFRC. They are complete products, shipped from the manufacturer with the frame and glazing already assembled. These products may be listed in the directory with their U factors, but without an SHGC. As of January 1, 2001, the number of these products is very small and includes only those with non planar or translucent glazing. To determine compliance with the building efficiency standards, the center of glass SHGC from the manufacturer's documentation must be converted to an SHGC that includes the framing effect. Use the following equation:

$$\text{SHGC}_{\text{fen}} = 0.11 + 0.81 \times \text{SHGC}_c$$

Where:

SHGC_c is the SHGC for the center of glass alone, and

SHGC_{fen} is the SHGC for the fenestration including glass and frame.

NI.1.2 Responsibilities for SHGC Compliance

This section describes the responsibilities of energy consultants, designers, architects, builders, installers, and building departments when this alternative calculation method is used for determining compliance with SHGC requirements.

NI.1.2.1 Energy Consultants, Designers, Architects

Products with SHGCs Certified to NFRC

SHGCs can be found in the NFRC Certified Products Directory, SV section. Contact NFRC at 301-589-6372 for a copy of the directory or go to NFRC's website at www.nfrc.org for an online database of the directory.

Field Fabricated Fenestration, Site Assembled Fenestration and Site-Built Fenestration Products without SHGC Certified to Rated Using NFRC Procedures

The procedure described below applies only to skylights and to site-built fenestration in buildings with less than 10,000 ft² of site-built fenestration.

does not apply to site-assembled vertical glazing in buildings with (a) 100,000 sf or more of conditioned floor area and (b) 10,000 sf or more of vertical fenestration area. For these glazing assemblies, use the NFRC 100SB Label Certificate procedure described above. (For projects where the building has 100,000 sf or more of conditioned space and there is 10,000 sf or more of fenestration area, the SHGC of the vertical glazing must be obtained using NFRC 100SB and must be verified by a Label Certificate for Site-Built Products. The Label Certificate must be included with the plans or be provided on site at the time of inspection.)

To determine compliance with the efficiency standards, the center of glass SHGC from the manufacturer's documentation for the proposed glazing must be converted to an SHGC_{fen} for the fenestration that includes the framing effect.

For the Prescriptive compliance method, the SHGC_{fen} is then entered into the prescriptive ENV-1 form, Part 2 of 2 and must appear on the building plans.

For the Performance compliance method, the SHGC_{fen} output information printed on the Performance ENV-1 form must be listed on the building plans. The PERF-1 and Performance ENV-1 forms must appear on the plans. The building plan window schedule list must indicate the proposed total SHGC_{fen} values for each fenestration assembly, and these values must be equal to the SHGCs listed on the Performance ENV-1 computer form. (Note: an under-calculation of space conditioning energy can result from entering either too low or too high an SHGC_{fen} for the product.) ~~The proposed design SHGC_{fen} values are entered into the computer program to automatically generate the energy budget of the standard design and the energy use of the proposed design. The building complies if the total energy use of the proposed design is the same or less than the standard design energy budget.~~

Permit applications must include heat gain documentation for the Building Plan Checker. This documentation must include a copy of the manufacturer's documentation showing the SHGC_c, center of glass alone and the calculation used to determine the SHGC_{fen}. If the proposed design uses multiple fenestration products or site-assembled fenestration products, a calculation for each different SHGC_{fen} must be attached to the plans along with each glass unit manufacturer's documentation.

Building plans shall identify all site-built fenestration and all site-built fenestration without SHGCs rated using NFRC procedures.

Mixed Fenestration Types

If mixed fenestration is included in the compliance analysis, then the compliance submittal must demonstrate which are certified fenestration products and which are non-certified fenestration or site-built assembled fenestration products. The manufacturer's documentation and calculations for each product must be included in the submittal, and either the ENV-1 or PERF-1 form must be included on the building plans.

NI.1.2.2 Builder and Installer Responsibilities

The builder is responsible for assuring that the glass documentation showing the SHGC used for determining compliance is provided to the installer. The builder is responsible for obtaining an NFRC Label Certificate for Site-Built Products for the building's site-built fenestration vertical glazing if the building is 100,000 sf or more and has 10,000 sf² or more of site-built fenestration vertical glazing.

The builder is also responsible for assuring that the persons preparing compliance documentation are specifying products that the builder intends to install. The builder must assure that the glazing contractor installs the glass with the same SHGC_c as used for compliance and that the building inspector is provided with manufacturers' documentation showing the SHGC_c for the actual glass product installed. The builder should verify that these fenestration products are clearly shown on the building plans before fenestration products are purchased and installed.

NI.1.2.3 Building Department Responsibilities

Plan Checker

The building department plan checker is responsible for assuring that the plans identify all site-built fenestration which is site-assembled and which is not.

The plan-checker is responsible for verifying that for skylights and site-built fenestration using the alternate default SHGC calculation:

1. the SHGC_{fen} and SHGC_c for non-certified fenestration products or site-assembled products is are identified on the plans, ~~that~~
2. calculations have been provided showing the conversion from SHGC_c to SHGC_{fen}, ~~and that~~
3. manufacturer documentation of the SHGC_c has been provided for each of the fenestration products using alternate default SHGC calculations, to be installed and
4. the building has less than 10,000 ft² of site-built fenestration.

Plans should be consistent with the compliance documentation, the calculations showing the conversion from SHGC_c to SHGC_{fen}, and Prescriptive ENV-1 Part 2 of 2 or Performance ENV-1.

Building Inspector

The building department field inspector is responsible for ~~as~~suring that the building using an alternate default SHGC calculation has less than 10,000 ft² of site-built fenestration.

~~manufacturer's documentation has been provided for the installed fenestration. The inspector is responsible for checking the NFRC label for manufactured fenestration products, or the NFRC 100SB Label Certificate for site-built products where appropriate as described below [see "Energy Consultants, Designers, Architects: Products with SHGCs Certified to NFRC" above].~~

~~1. All manufactured fenestration products must have either an NFRC label or manufacturer's label with default SHGCs from Table 1-E.~~

~~2. All site assembled fenestration products in buildings 100,000 sf of conditioned floor area or more and 10,000 sf of vertical fenestration area or more must have either an NFRC Label Certificate for Site-Built Fenestration Products or a manufacturer's certificate with a default SHGC from Table 1-E.~~

~~3. Site assembled vertical fenestration products in buildings less than 100,000 sf, or buildings with less than 10,000 sf of vertical glazing, may use either of the rating/labeling methods described in (b) above, or the SHGC_{fen} calculation method described in this section.~~

~~4. Horizontal glazing that does not have a certified NFRC SHGC may use any of the above methods for determining and labeling or certifying the SHGC.~~

The field inspector is responsible for ~~as~~suring that the ~~certified SHGC, or~~ SHGC_c and SHGC_{fen} for the installed fenestration is consistent with the plans, the Prescriptive ENV-1 Part 2 of 2 or the Performance PER-1 and Performance ENV-1, and that manufacturer documentation is consistent with the product installed in the building. ~~Plans shall indicate which fenestration is site-assembled or is a fenestration product without SHGCs certified to the NFRC.~~

NI.2 Thermal Transmittance (U-Factor)

Table NI-1 provides default U-factors for skylights and ~~for~~ site-built fenestration in buildings ~~with less than 10,000 ft² of site-built fenestration covered by the Nonresidential Energy Standards. The default table may be used only for the following:~~

- ~~□ Site-assembled and field fabricated glazed wall systems in buildings covered by the Nonresidential Energy Standards that have less than 100,000 square feet of conditioned floor area and less than 10,000 square feet of vertical glazing.~~
- ~~□ Skylights in buildings covered by the Nonresidential Energy Standards.~~
- ~~□ The default Table NI-1 is consistent with default U-factors published in Table 45, Chapter 3029, ASHRAE Fundamentals Handbook, 20011997, which is referenced in the Energy Standards. Fenestration products fitting the two descriptions above may still use U-factors obtained through NFRC if available.~~

NI.2.1 Responsibilities for U-factor Compliance

This section describes the responsibilities of energy consultants, designers, architects, builders, installers, and building departments when Table NI-1 is used for determining compliance with the U-factor requirements of the Efficiency Standards.

NI.2.1.1 Energy Consultants, Designers, Architects

~~Products with U-factor Certified to NFRC~~

~~U-factor values can be found in the NFRC Certified Products Directory. Contact NFRC at 301-589-6372 for a copy of the directory or go to NFRC's website at www.nfrc.org for an online database of the directory.~~

Field Fabricated Fenestration, Site-Assembled Fenestration and Fenestration Products Site-Built Fenestration without U-factor Certified to Rated Using NFRC Procedures

~~The procedure described below applies only to skylights and to site-built fenestration in buildings with less than 10,000 ft² of site-built fenestration.~~ To determine compliance with the efficiency standards, the Glazing Type and Frame Type shown in Table NI-1 must be identified from the manufacturer's documentation for the proposed glazing.

For the Prescriptive compliance method, the U-factor must be selected from Table NI-1 for this Glazing Type and Frame Type and entered into the prescriptive ENV-1 form, Part 2 of 2, and must appear on the building plans.

For the Performance compliance method, the U-factor output information printed on the Performance ENV-1 form must be listed on the building plans. The PERF-1 and Performance ENV-1 forms must appear on the plans. The building plan window schedule list must indicate the proposed total U-factors for each fenestration assembly, and these values must be equal to or less than the U-factors listed on the Performance ENV-1 computer form. ~~The proposed design U-factors are entered into the computer program to automatically generate the energy use of the proposed design. The building complies if the total energy use of the proposed design is the same or less than the standard design energy budget.~~

Permit applications must include fenestration U-factor documentation for the Building Plan Checker. This documentation must include a copy of the manufacturer's documentation showing the Glazing Type information – number of panes, spacing of panes, glass type, gas fill type, coating emissivity and location – and the Frame Type – frame material type, presence of thermal breaks, and identification of structural glazing (glazing with no frame) that is used to determine the U-factor. If the proposed design uses multiple fenestration products or site-assembled fenestration products, manufacturer's documentation for each different U-factor for each glass unit must be attached to the plans ~~for each glass unit~~. Manufacturer's documentation must be provided for each U-factor used for compliance.

Building plans shall identify all site-built fenestration and all site-built fenestration without U-factors rated using NFRC procedures.

Mixed Fenestration Types

If mixed fenestration is included in the compliance analysis, then the compliance submittal must demonstrate which are certified fenestration products and which are non-certified fenestration or site-assembled fenestration products. The manufacturer's documentation and calculations for each product must be included in the submittal, and either the ENV-1 or PERF-1 form must be included on the building plans.

NI.2.1.2 Builder and Installer Responsibilities

The builder is responsible for asensuring that the glass documentation showing the U-factor used for determining compliance is provided to the installer. The builder is responsible for asensuring that the persons preparing compliance documentation are specifying products that the builder intends to install. The builder is also responsible for asensuring that the installer installs glass with U-factors the same or lower than the U-factors as-used for compliance and asensuring that the field inspector for the building department is provided with manufacturer's documentation showing the U-factor and method of determining U-factor for the actual fenestration product installed. The builder should verify that these fenestration products are clearly shown on the building plans before fenestration products are purchased and installed.

NI.2.1.3 Building Department Responsibilities

Plan Checker

The building department plan checker is responsible for ~~as~~suring that the plans identify ~~all site-built fenestration, which fenestration is site-assembled and which is not. The plan checker is responsible for verifying that the U-factor~~

~~The plan checker shall ensure that for skylights and site-built fenestration using alternate default U-factors: non-certified fenestration products or site-assembled products is~~

1. ~~U-factors are~~ identified on the plans, ~~that~~
2. ~~the Glazing Type and Frame Type and Table NI-1 have been provided showing documenting the method of determining the U-factor, and that~~
3. ~~manufacturer documentation of the U-factor Glazing Type and Frame Type has been provided for the each of the fenestration products using alternate default U-factors, and to be installed.~~
4. ~~the building has less than 10,000 ft² of site-built fenestration.~~

Plans should be consistent with the compliance documentation, the Glazing Type and Frame Type and Table NI-1 values, and Prescriptive ENV-1 Part 2 of 2 or Performance ENV-1.

Building Inspector

~~The building department field inspector is responsible for ensuring that the building using an alternate default U-factor has less than 10,000 ft² of site-built fenestration.~~

The building department field inspector is responsible for ~~assuring ensuring~~ that manufacturer's documentation has been provided for the installed fenestration. The field inspector is responsible for ~~as~~suring that the U-factor for the installed fenestration is consistent with the plans, the Prescriptive ENV-1 Part 2 of 2 or the Performance PER-1, and Performance ENV-1, and that manufacturer documentation is consistent with the product installed in the building.

~~Plans shall indicate which fenestration is site-assembled or is a fenestration product without U-factor certified to NFRC.~~

Table NI-1 – Assembly Alternate U-Factors for Skylights and Eligible¹ Site-Built Fenestration Unlabeled Glazed Wall Systems (Site-Built Windows) and Unlabeled Skylights

Product Type		Vertical Installation				Sloped Installation						
		Unlabeled Glazed Wall Systems (Site Built Windows) (includes site assembled fixed windows only, does not include operable windows)				Unlabeled Skylight with Curb (includes glass/plastic, flat/domed, fixed/operable)			Unlabeled Skylight without Curb (includes glass/plastic, flat/domed, fixed/operable)			
Frame Type		Aluminum without Thermal Break	Aluminum with Thermal Break	Wood/Vinyl	Structural Glazing	Aluminum without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/Vinyl	Aluminum without Thermal Break	Aluminum with Thermal Break	Structural Glazing
ID	Glazing Type											
1	Single Glazing											
1	1/8" glass	1.22	1.11	0.98	1.11	1.98	1.89	1.75	1.47	1.36	1.25	1.25
2	1/4" acrylic/polycarb	1.08	0.96	0.84	0.96	1.82	1.73	1.60	1.31	1.21	1.10	1.10
3	1/8" acrylic/polycarb	1.15	1.04	0.91	1.04	1.90	1.81	1.68	1.39	1.29	1.18	1.18
4	Double Glazing											
4	1/4" airspace	0.79	0.68	0.56	0.63	1.31	1.11	1.05	0.84	0.82	0.70	0.66
5	1/2" airspace	0.73	0.62	0.50	0.57	1.30	1.10	1.04	0.84	0.81	0.69	0.65
6	1/4" argon space	0.75	0.64	0.52	0.60	1.27	1.07	1.00	0.80	0.77	0.66	0.62
7	1/2" argon space	0.70	0.59	0.48	0.55	1.27	1.07	1.00	0.80	0.77	0.66	0.62
8	Double Glazing, e=0.60 on surface 2 or 3											
8	1/4" airspace	0.76	0.65	0.53	0.61	1.27	1.08	1.01	0.81	0.78	0.67	0.63
9	1/2" airspace	0.69	0.58	0.47	0.54	1.27	1.07	1.00	0.80	0.77	0.66	0.62
10	1/4" argon space	0.72	0.61	0.49	0.56	1.23	1.03	0.97	0.76	0.74	0.63	0.58
11	1/2" argon space	0.67	0.56	0.44	0.51	1.23	1.03	0.97	0.76	0.74	0.63	0.58
12	Double Glazing, e=0.40 on surface 2 or 3											
12	1/4" airspace	0.74	0.63	0.51	0.58	1.25	1.05	0.99	0.78	0.76	0.64	0.60
13	1/2" airspace	0.66	0.55	0.44	0.51	1.24	1.04	0.98	0.77	0.75	0.64	0.59
14	1/4" argon space	0.69	0.57	0.46	0.53	1.18	0.99	0.92	0.72	0.70	0.58	0.54
15	1/2" argon space	0.63	0.51	0.40	0.47	1.20	1.00	0.94	0.74	0.71	0.60	0.56
16	Double Glazing, e=0.20 on surface 2 or 3											
16	1/4" airspace	0.70	0.59	0.48	0.55	1.20	1.00	0.94	0.74	0.71	0.60	0.56
17	1/2" airspace	0.62	0.51	0.39	0.46	1.20	1.00	0.94	0.74	0.71	0.60	0.56
18	1/4" argon space	0.64	0.53	0.42	0.49	1.14	0.94	0.88	0.68	0.65	0.54	0.50
19	1/2" argon space	0.57	0.46	0.35	0.42	1.15	0.95	0.89	0.68	0.66	0.55	0.51
20	Double Glazing, e=0.10 on surface 2 or 3											
20	1/4" airspace	0.68	0.57	0.45	0.52	1.18	0.99	0.92	0.72	0.70	0.58	0.54
21	1/2" airspace	0.59	0.48	0.37	0.44	1.18	0.99	0.92	0.72	0.70	0.58	0.54
22	1/4" argon space	0.62	0.51	0.39	0.46	1.11	0.91	0.85	0.65	0.63	0.52	0.47
23	1/2" argon space	0.55	0.44	0.33	0.39	1.13	0.93	0.87	0.67	0.65	0.53	0.49
24	Triple Glazing											
24	Double Glazing, e=0.05 on surface 2 or 3											
24	1/4" airspace	0.67	0.56	0.44	0.51	1.17	0.97	0.91	0.70	0.68	0.57	0.52
25	1/2" airspace	0.57	0.46	0.35	0.42	1.17	0.98	0.91	0.71	0.69	0.58	0.53
26	1/4" argon space	0.60	0.49	0.38	0.44	1.09	0.89	0.83	0.63	0.61	0.50	0.45
27	1/2" argon space	0.53	0.42	0.31	0.38	1.11	0.91	0.85	0.65	0.63	0.52	0.47

Product Type	Vertical Installation				Sloped Installation							
	Unlabeled Glazed Wall Systems (Site Built Windows) (includes site assembled fixed windows only, does not include operable windows)				Unlabeled Skylight with Curb (includes glass/plastic, flat/domed, fixed/operable)				Unlabeled Skylight without Curb (includes glass/plastic, flat/domed, fixed/operable)			
	Aluminum without Thermal Break	Aluminum with Thermal Break	Wood/Vinyl	Structural Glazing	Aluminum without Thermal Break	Aluminum with Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/Vinyl	Aluminum without Thermal Break	Aluminum with Thermal Break	Structural Glazing	
28	1/4" airspaces	0.63	0.52	0.41	0.47	1.12	0.89	0.84	0.64	0.64	0.53	0.48
29	1/2" airspaces	0.57	0.46	0.35	0.41	1.10	0.87	0.81	0.61	0.62	0.51	0.45
30	1/4" argon spaces	0.60	0.49	0.38	0.43	1.09	0.86	0.80	0.60	0.61	0.50	0.44
31	1/2" argon spaces	0.55	0.45	0.34	0.39	1.07	0.84	0.79	0.59	0.59	0.48	0.42
	Triple Glazing, e=0.20 on surface 2,3,4, or 5											
32	1/4" airspaces	0.59	0.48	0.37	0.42	1.08	0.85	0.79	0.59	0.60	0.49	0.43
33	1/2" airspaces	0.52	0.41	0.30	0.35	1.05	0.82	0.77	0.57	0.57	0.46	0.41
34	1/4" argon spaces	0.54	0.44	0.33	0.38	1.02	0.79	0.74	0.54	0.55	0.44	0.38
35	1/2" argon spaces	0.49	0.38	0.28	0.33	1.01	0.78	0.73	0.53	0.54	0.43	0.37
	Triple Glazing, e=0.20 on surfaces 2 or 3 and 4 or 5											
36	1/4" airspaces	0.55	0.45	0.34	0.39	1.03	0.80	0.75	0.55	0.56	0.45	0.39
37	1/2" airspaces	0.48	0.37	0.26	0.31	1.01	0.78	0.73	0.53	0.54	0.43	0.37
38	1/4" argon spaces	0.50	0.39	0.29	0.34	0.99	0.75	0.70	0.50	0.51	0.40	0.35
39	1/2" argon spaces	0.45	0.34	0.24	0.29	0.97	0.74	0.69	0.49	0.50	0.39	0.33
	Triple Glazing, e=0.10 on surfaces 2 or 3 and 4 or 5											
40	1/4" airspaces	0.54	0.43	0.32	0.37	1.01	0.78	0.73	0.53	0.54	0.43	0.37
41	1/2" airspaces	0.46	0.35	0.25	0.29	0.99	0.76	0.71	0.51	0.52	0.41	0.36
42	1/4" argon spaces	0.48	0.38	0.27	0.32	0.96	0.73	0.68	0.48	0.49	0.38	0.32
43	1/2" argon spaces	0.42	0.32	0.21	0.26	0.95	0.72	0.67	0.47	0.48	0.37	0.31
	Quadruple Glazing, e=0.10 on surfaces 2 or 3 and 4 or 5											
44	1/4" airspaces	0.49	0.38	0.28	0.33	0.97	0.74	0.69	0.49	0.50	0.39	0.33
45	1/2" airspaces	0.43	0.32	0.22	0.27	0.94	0.71	0.66	0.46	0.47	0.36	0.30
46	1/4" argon spaces	0.45	0.34	0.24	0.29	0.93	0.70	0.65	0.45	0.46	0.35	0.30
47	1/2" argon spaces	0.41	0.30	0.20	0.24	0.91	0.68	0.63	0.43	0.44	0.33	0.28
48	1/4" krypton spaces	0.41	0.30	0.20	0.24	0.88	0.65	0.60	0.40	0.42	0.31	0.25

¹ To be eligible, the site-built fenestration must be in a building with less than 10,000 ft² of site-built fenestration.

ACM NJ-2005

Appendix NJ - Acceptance Requirements for Nonresidential Buildings

NJ.1 Purpose and Scope

ACM NJ defines acceptance procedures that must be completed before credit can be claimed for certain compliance measures. The procedures apply to nonresidential, high-rise residential and hotel/motel buildings as defined by the California Energy Commission's Energy Efficiency Standards for Nonresidential Buildings.

NJ.2 Introduction

Acceptance Requirements are defined as the application of targeted inspection checks and functional and performance testing conducted to determine whether specific building components, equipment, systems, and interfaces between systems conform to the criteria set forth in the Standards and to related construction documents (plans or specifications). Acceptance Requirements can effectively improve code compliance and help determine whether equipment meets operational goals and whether it should be adjusted to increase efficiency and effectiveness.

This section describes the process for completing the Acceptance Requirements. The steps include the following:

- Document plans showing sensor locations, devices, control sequences and notes,
- Review the installation, perform acceptance tests and document results, and
- Document the operating and maintenance information, complete installation certificate and indicate test results on the Certificate of Acceptance, and submit the Certificate to the building department prior to receive a final occupancy permit.

Acceptance testing is not intended to take the place of commissioning or test and balance procedures that a building owner might incorporate into a building project. It is an adjunct process focusing only on demonstrating compliance with the Standards.

The installing contractor, engineer of record or owners agent shall be responsible for reviewing the plans and specifications to assure they conform to the Acceptance Requirements. This is typically done prior to signing a Certificate of Compliance.

The installing contractor, engineer of record or owners agent shall be responsible for providing all necessary instrumentation, measurement and monitoring, and undertaking all required acceptance requirement procedures. They shall be responsible for correcting all performance deficiencies and again implementing the acceptance requirement procedures until all specified systems and equipment are performing in accordance with the Standards.

The installing contractor, engineer of record or owners agent shall be responsible for documenting the results of the acceptance requirement procedures including paper and electronic copies of all measurement and monitoring results. They shall be responsible for performing data analysis, calculation of performance indices and crosschecking results with the requirements of the Standard. They shall be responsible for issuing a Certificate of Acceptance. Building departments shall not release a final Certificate of Occupancy until a Certificate of Acceptance is submitted that demonstrates that the specified systems and equipment have been shown to be performing in accordance with the Standards. The installing contractor, engineer of record or owners agent upon completion of undertaking all required acceptance requirement procedures shall record

their State of California Contractor's License number or their State of California Professional Registration License Number on each Certificate of Acceptance that they issue.

NJ.3 Outdoor Air

NJ.3.1 Variable Air Volume Systems Outdoor Air Acceptance

NJ.3.1.1 Construction Inspection

Prior to Acceptance Testing, verify and document the following:

- Outside air flow station is calibrated OR a calibration curve of outside air vs. outside air damper position, inlet vane signal, or VFD signal was completed during system TAB procedures.

NJ.3.1.2 Equipment Start-up

Step 1: If the system has an outdoor air economizer, force the economizer high limit to disable economizer control (e.g. for a fixed drybulb high limit, lower the setpoint below the current outdoor air temperature)

Step 2: Drive all VAV boxes to the greater of the minimum airflow or 30% of the total design airflow. Verify and document the following:

- Measured outside airflow CFM corresponds to no less than 90% of the total value found on the Standards Mechanical Plan Check document MECH-3, Column H or Column I (which ever is greater).
- System operation stabilizes within 15 minutes after test procedures are initiated (no hunting).

Step 3: Drive all VAV boxes to achieve design airflow. Verify and document the following:

- Measured outside airflow CFM corresponds to no less than 90% of the total value found on Standards Mechanical Plan Check document MECH-3, Column H or Column I (which ever is greater).
- System operation stabilizes within 15 minutes after test procedures are initiated (no hunting).

NJ.3.2 Constant Volume System Outdoor Air Acceptance

NJ.3.2.1 Construction Inspection

Prior to Acceptance Testing, verify and document the following:

- The system has a fixed or motorized minimum outdoor air damper, or an economizer capable of maintaining a minimum outdoor air damper position.

NJ.3.2.2 Equipment Testing

Step 1: If the system has an outdoor air economizer, force the economizer high limit to disable economizer control (e.g. for a fixed drybulb high limit, lower the setpoint below the current outdoor air temperature)

- Measured outside airflow CFM with damper at minimum position corresponds to no less than 90% of the total value found on the Standards Mechanical Plan Check document MECH-3, Column H or Column I (which ever is greater).

NJ.4 Packaged HVAC Systems

Acceptance requirements apply only to constant volume, direct expansion (DX) packaged systems with gas furnaces or heat pumps.

NJ.4.1 Constant Volume Packaged HVAC Systems Acceptance

NJ.4.1.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- Thermostat is located within the zone that the HVAC system serves.
- Space temperature thermostat is factory-calibrated (proof required) or field-calibrated.
- Appropriate temperature deadband has been programmed.
- Appropriate occupied, unoccupied, and holiday schedules have been programmed.
- Appropriate pre-occupancy purge has been programmed per Standards Section 121(c)2.
- Economizer lockout control sensor, if applicable, is factory-calibrated (proof required) or field-calibrated and setpoint properly set (refer to the *ECONOMIZERS* acceptance requirements section for detail).
- Demand control ventilation controller, if applicable, is factory-calibrated (proof required) or field-calibrated and setpoint properly set (refer to the *DEMAND CONTROL VENTILATION* acceptance requirements section for detail).

NJ.4.1.2 Equipment Testing

Step 1: Simulate heating load during occupied condition (e.g. by setting time schedule to include actual time and placing thermostat heating setpoint above actual temperature). Verify and document the following:

- Supply fan operates continually during occupied condition.
- Gas-fired furnace, heat pump or electric heater, if applicable, stages on.
- No cooling is provided by the unit.
- Outside air damper is open to the minimum position.

Step 2: Simulate “no-load” during occupied condition (e.g. by setting time schedule to include actual time and placing thermostat heating setpoints below actual temperature and cooling setpoint below actual temperature). Verify and document the following:

- Supply fan operates continually during occupied condition.
- Neither heating or cooling is provided by the unit.
- Outside air damper is open to the minimum position.

Step 3: If there is an economizer, simulate cooling load and economizer operation, if applicable, during occupied condition (e.g. by setting time schedule to include actual time and placing thermostat cooling setpoint below actual temperature). Verify and document the following:

- Supply fan operates continually during occupied condition.
- Refer to the *ECONOMIZERS* acceptance requirements section for testing protocols.
- No heating is provided by the unit.

Step 4: If there is no economizer, simulate cooling load during occupied condition (e.g. by setting time schedule to include actual time and placing thermostat cooling setpoint below actual temperature). Verify and document the following:

- Supply fan operates continually during occupied condition.
- Compressor(s) stage on.
- No heating is provided by the unit.
- Outside air damper is open to the minimum position.

Step 5: Change the time schedule force the unit into unoccupied mode. Verify and document the following:

- Supply fan turns off.
- Outside air damper closes completely.

Step 6: Simulate heating load during setback conditions (e.g. by setting time schedule to exclude actual time and placing thermostat setback heating setpoint above actual temperature). Verify and document the following:

- Supply fan cycles on.
- Gas-fired furnace, heat pump or electric heater, if applicable, stages on.
- No cooling is provided by the unit.
- Supply fan cycles off when heating equipment is disabled.

Step 7: If there is an economizer, simulate cooling load and economizer operation, if applicable, during unoccupied condition (e.g. by setting time schedule to exclude actual time and placing thermostat setup cooling setpoint below actual temperature). Verify and document the following:

- Supply fan cycles on.
- Refer to the *ECONOMIZERS* acceptance requirements section for testing protocols.
- Supply fan cycles off when call for cooling is satisfied (simulated by lowering the thermostat setpoint to below actual temperature).
- Outside air damper closes when unit cycles off.

Step 8: If there is no economizer, simulate cooling load during setup condition (e.g. by setting time schedule to exclude actual time and placing thermostat setup cooling setpoint above actual temperature). Verify and document the following:

- Supply fan cycles on.
- Compressor(s) stage on to satisfy cooling space temperature setpoint.
- No heating is provided by the unit.
- Supply fan cycles off when cooling equipment is disabled.

Step 9: Simulate manual override during unoccupied condition (e.g. by setting time schedule to exclude actual time or by pressing override button). Verify and document the following:

- System reverts to “occupied” mode and operates as described above to satisfy a heating, cooling, or no load condition.
- System turns off when manual override time period expires.

NJ.5. Air Distribution Systems

Acceptance requirements apply only to systems covered by Section 144(k).

NJ.5.1 Air Distribution Acceptance

NJ.5.1.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- Drawbands are either stainless steel worm-drive hose clamps or UV-resistant nylon duct ties.

- Flexible ducts are not constricted in any way (for example pressing against immovable objects or squeezed through openings).
- Duct leakage tests shall be performed before access to ductwork and associated connections are blocked by permanently installed construction material.
- Joints and seams are not sealed with a cloth back rubber adhesive tape unless used in combination with mastic and drawbands.
- Duct R-values are verified.
- Insulation is protected from damage and suitable for outdoor service if applicable.

NJ.5.1.2 Equipment Testing

Step 1: Perform duct leakage test per 2003 Nonresidential ACM Approved Manual, Appendix NG, Section 4.3.8.2. Certify the following:

- Duct leakage conforms to the requirements of Section 144(k)..

Step 2: Obtain HERS Rater field verification as required by Chapter 7 and Appendix NG.

NJ.6. Lighting Control Systems

Lighting control testing is performed on:

- Manual Daylighting Controls.
- Automatic Daylighting Controls.
- Occupancy Sensors.
- Automatic Time-switch Control.

NJ.6.1 Automatic Daylighting Controls Acceptance

NJ.6.1.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- All control devices (photocells) have been properly located, factory-calibrated (proof required) or field-calibrated and set for appropriate set points and threshold light levels.
- Installer has provided documentation of setpoints, setting and programming for each device.
- Luminaires located in either a horizontal daylit area(s) or a vertical daylit area(s) are powered by a separate lighting circuit from non-daylit areas.

NJ.6.1.2 Equipment Testing

Continuous Dimming Control Systems

Step 1: Simulate bright conditions for a continuous dimming control system. Verify and document the following:

- Lighting power reduction is at least 65% under fully dimmed conditions.
- At least one control step reduces the lighting power by at least 30%.
- Only luminaires in daylit zone are affected by daylight control.
- Automatic daylight control system reduces the amount of light delivered to the space uniformly.

- Dimming control system provides reduced flicker operation over the entire operating range per Standards Section 119(e)2.
- Lumen measurements in the space, location of measurements and specific device settings, program settings and other measurements are documented.

Step 2: Simulate dark conditions for a continuous dimming control system. Verify and document the following:

- Automatic daylight control system increases the amount of light delivered to the space uniformly.
- Dimming control system provides reduced flicker operation over the entire operating range per Standards Section 119(e)2.
- Lumen measurements in the space, location of measurements and specific device settings, program settings and other measurements are documented.

Stepped Dimming Control Systems

Step 1: Simulate bright conditions for a stepped dimming control system. Verify and document the following:

- Lighting power reduction is at least 50% under fully dimmed conditions.
- Only luminaires in daylit zone are affected by daylight control.
- Automatic daylight control system reduces the amount of light delivered to the space relatively uniformly as per Section 131(b).
- Automatic daylight control system reduces the amount of light delivered to the space per manufacturer's specifications for power level versus light level.
- Minimum time delay between step changes is 3 minutes to prevent short cycling.
- Lumen measurements in the space, location of measurements and specific device settings, program settings and other measurements are documented.

Step 2: Simulate dark conditions for a stepped dimming control system. Verify and document the following:

- Automatic daylight control system increases the amount of light delivered to the space per manufacturer's specifications for power level versus light level.
- Stepped dimming control system provides reduced flicker over the entire operating range per Standards Section 119(e)2.
- Minimum time delay between step changes is 3 minutes to prevent short cycling.
- Lumen measurements in the space, location of measurements and specific device settings, program settings and other measurements are documented.

Stepped Switching Control Systems

Step 1: Simulate bright conditions for a stepped switching control system. Verify and document the following:

- Lighting power reduction is at least 50% under fully switched conditions per Standards Section 119(e)1.
- Only luminaires in daylit zone are affected by daylight control.
- Automatic daylight control system reduces the amount of light delivered to the space relatively uniformly as per Section 131(b).
- Automatic daylight control system reduces the amount of light delivered to the space per manufacturer's specifications for power level versus light level.
- Single- or multiple-stepped switching controls provide a dead band of at least three minutes between switching thresholds to prevent short cycling.

- Lumen measurements in the space, location of measurements and specific device settings, program settings and other measurements are documented.

Step 2: Simulate dark conditions for a stepped switching control system. Verify and document the following:

- Automatic daylight control system increases the amount of light delivered to the space per manufacturer's specifications for power level versus light level.
- Single- or multiple-stepped switching controls provide a dead band of at least three minutes between switching thresholds to prevent short cycling.
- Lumen measurements in the space, location of measurements and specific device settings, program settings and other measurements are documented.

NJ.6.2 Occupancy Sensor Acceptance

NJ.6.2.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- Occupancy sensitivity has been located to minimize false signals.
- Occupancy sensors do not encounter any obstructions that could adversely affect desired performance.
- Ultrasound occupancy sensors do not emit audible sound.

NJ.6.2.2 Equipment Testing

Step 1: For a representative sample of building spaces, simulate an unoccupied condition. Verify and document the following:

- Lights controlled by occupancy sensors turn off within a maximum of 30 minutes from the start of an unoccupied condition per Standard Section 119(d).
- The occupant sensor does not trigger a false "on" from movement in an area adjacent to the controlled space or from HVAC operation.
- Signal sensitivity is adequate to achieve desired control.

Step 2: For a representative sample of building spaces, simulate an occupied condition. Verify and document the following:

- Status indicator or annunciator operates correctly.
- Lights controlled by occupancy sensors turn on immediately upon an occupied condition, OR sensor indicates space is "occupied" and lights are turned on manually (automatic OFF and manual ON control strategy).

NJ.6.3 Manual Daylighting Controls Acceptance

NJ.6.3.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- If dimming ballasts are specified for light fixtures within the daylit area, make sure they meet all the Standards requirements, including "reduced flicker operation" for manual dimming control systems.

NJ.6.3.2 Equipment Testing

Step 1: Perform manual switching control. Verify and document the following:

- Manual switching or dimming achieves a lighting power reduction of at least 50%.
- The amount of light delivered to the space is uniformly reduced.

NJ.6.4 Automatic Time Switch Control Acceptance

NJ.6.4.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- Automatic time switch control is programmed with acceptable weekday, weekend, and holiday (if applicable) schedules.
- Document for the owner automatic time switch programming including weekday, weekend, holiday schedules as well as all set-up and preference program settings.
- Verify the correct time and date is properly set in the time switch.
- Verify the battery is installed and energized.
- Override time limit is no more than 2 hours.

NJ.6.4.2 Equipment Testing

Step 1: Simulate occupied condition. Verify and document the following:

- All lights can be turned on and off by their respective area control switch.
- Verify the switch only operates lighting in the ceiling-height partitioned area in which the switch is located.

Step 2: Simulate unoccupied condition. Verify and document the following:

- All non-exempt lighting turn off per Section 131 (d)1.
- Manual override switch allows only the lights in the selected ceiling height partitioned space where the override switch is located, to turn on or remain on until the next scheduled shut off occurs.
- All non-exempt lighting turns off.

NJ.7. Air Economizer Controls

Economizer testing is performed on all built-up systems and on packaged systems per Standards Section 144 (e)1. Air economizers installed by the HVAC system manufacturer and certified to the commission as being factory calibrated and tested do not require field testing.

NJ.7.1 Economizer Acceptance

NJ.7.1.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- Economizer lockout setpoint complies with Table 144-C per Standards Section 144 (e) 3.
- System controls are wired correctly to ensure economizer is fully integrated (i.e. economizer will operate when mechanical cooling is enabled).

- Economizer lockout control sensor location is adequate (open to air but not exposed to direct sunlight nor in an enclosure; away from sources of building exhaust; at least 25 feet away from cooling towers).
- Relief fan system (if applicable) operates only when the economizer is enabled.
- If no relief fan system is installed, barometric relief dampers are installed to relieve building pressure when the economizer is operating.

NJ.7.1.2 Equipment Testing

Step 1: Simulate a cooling load and enable the economizer by adjusting the lockout control (fixed or differential dry-bulb or enthalpy sensor depending on system type) setpoint. Verify and document the following:

- Economizer damper modulates opens per Standards Section 144 (e)1A to maximum position to satisfy cooling space temperature setpoint.
- Return air damper modulates closed and is completely closed when economizer damper is 100% open.
- Economizer damper is 100% open before mechanical cooling is enabled.
- Relief fan is operating or relief dampers freely swing open.
- Mechanical cooling is only enabled if cooling space temperature setpoint is not met with economizer at 100% open.
- Doors are not pushed ajar from over pressurization.

Step 2: Continue from Step 1 and disable the economizer by adjusting the lockout control (fixed or differential dry-bulb or enthalpy sensor depending on system type) setpoint. Verify and document the following:

- Economizer damper closes to minimum position.
- Return air damper opens to normal operating position.
- Relief fan shuts off or relief dampers close.
- Mechanical cooling remains enabled until cooling space temperature setpoint is met.

NJ.8. Demand Control Ventilation (DCV) Systems

Demand control ventilation is tested on package systems per Standards Section 121 (c)3.

NJ.8.1 Packaged Systems DCV Acceptance

NJ.8.1.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- Carbon dioxide control sensor is factory calibrated (proof required) or field-calibrated with an accuracy of no less than 75 ppm.
- The sensor is located in the room between 1ft and 6 ft above the floor.
- System controls are wired correctly to ensure proper control of outdoor air damper system.

NJ.8.1.2 Equipment Testing

Step 1: Simulate a high CO₂ load and enable the demand control ventilation by adjusting the demand control ventilation controller setpoint below ambient CO₂ levels. Verify and document the following:

- Outdoor air damper modulates opens per Standards to maximum position to satisfy outdoor air requirements specified in Section 121 (c)4, Equation 121-A.

Step 2: Continue from Step 1 and disable demand control ventilation by adjusting the demand control ventilation controller setpoint above ambient CO₂ levels. Verify and document the following:

- Outdoor air damper closes to minimum position.

NJ.9. Variable Frequency Drive Systems

NJ.9.1 Supply Fan Variable Flow Controls

NJ.9.1.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- Discharge static pressure sensor is factory calibrated (proof required) or field-calibrated with secondary source.
- Disable discharge static pressure reset sequences to prevent unwanted interaction while performing tests.

NJ.9.1.2 Equipment Testing

Step 1: Drive all VAV boxes to achieve design airflow. Verify and document the following:

- Witness proper response from supply fan (e.g. VFD ramps up to full speed; inlet vanes open full).
- Supply fan maintains discharge static pressure within +/-10% of setpoint.
- Measured maximum airflow corresponds to design and/or TAB report within +/-10%.
- System operation stabilizes within a reasonable amount of time after test procedures are initiated (no hunting).

Step 2: Drive all VAV boxes to minimum flow or to achieve 30% total design airflow whichever is larger. Verify and document the following:

- Witness proper response from supply fan (VFD slows fan speed; inlet vanes close).
- Supply fan maintains discharge static pressure within +/-10% of setpoint.
- System operation stabilizes within a reasonable amount of time after test procedures are initiated (no hunting).

NJ.10. Hydronic System Controls Acceptance

Hydronic controls Acceptance Testing will be performed on:

- Variable Flow Controls
- Automatic Isolation Controls
- Supply Water Temperature Reset Controls
- Water-loop Heat Pump Controls
- Variable Frequency Drive Control

NJ.10.1 Variable Flow Controls

NJ.10.1.1 Construction Inspection

Prior to Acceptance Testing, verify and document the following:

- Valve and piping arrangements were installed per the design drawings to achieve flow reduction requirements.
- Installed valve and hydronic connection pressure ratings meet specifications.
- Installed valve actuator torque characteristics meet specifications.

NJ.10.1.2 Equipment Testing

Step 1: Open all control valves. Verify and document the following:

- System operation achieves design conditions.

Step 2: Initiate closure of control valves. Verify and document the following:

- The design pump flow control strategy achieves flow reduction requirements.
- Ensure all valves operate correctly against the minimum flow system pressure condition.

NJ.10.2 Automatic Isolation Controls

NJ.10.2.1 Construction Inspection

Prior to Acceptance Testing, verify and document the following:

- Valve and piping arrangements were installed per the design drawings to achieve equipment isolation requirements.
- Installed valve and hydronic connection pressure ratings meet specifications.
- Installed valve actuator torque characteristics meet specifications.

NJ.10.2.2 Equipment Testing

Step 1: Open all control valves. Verify and document the following:

- System operation achieves design conditions.

Step 2: Initiate shut-down sequence on individual pieces of equipment. Verify and document the following:

- The design control strategy meets isolation requirements automatically upon equipment shut-down.
- Ensure all valves operate correctly at shut-off system pressure conditions.

NJ.10.3 Supply Water Temperature Reset Controls

NJ.10.3.1 Construction Inspection

Prior to Acceptance Testing, verify and document the following:

- ALL SENSORS HAVE BEEN CALIBRATED.
- Sensor locations are adequate to achieve accurate measurements.
- Installed sensors comply with specifications.

NJ.10.3.2 Equipment Testing

Step 1: Manually change design control variable to maximum setpoint. Verify and document the following:

- Chilled or hot water temperature setpoint is reset to appropriate value.
- Actual supply temperature changes to meet setpoint.

Step 2: Manually change design control variable to minimum setpoint. Verify and document the following:

- Chilled or hot water temperature setpoint is reset to appropriate value.
- Actual supply temperature changes to meet setpoint.

NJ.10.4 Water-loop Heat Pump Controls

NJ.10.4.1 Construction Inspection

Prior to Acceptance Testing, verify and document the following:

- Valves were installed per the design drawings to achieve equipment isolation requirements.
- Installed valve and hydronic connection pressure ratings meet specifications.
- Installed valve actuator torque characteristics meet specifications.
- All sensor locations comply with design drawings.
- All sensors are calibrated.
- VFD minimum speed setpoint exceeds motor manufacturer's requirements.
- VFD minimum speed setpoint should not be set below the pumping energy curve inflection point (i.e. combination of pump-motor-VFD efficiency at reduced load may cause power requirements to increase upon further reduction in load).

NJ.10.4.2 Equipment Testing

Step 1: Open all control valves. Verify and document the following:

- System operation achieves design conditions +/- 5%.
- VFD operates at 100% speed at full flow conditions.

Step 2: Initiate shut-down sequence on each individual heat pumps. Verify and document the following:

- Isolation valves close automatically upon unit shut-down.
- Ensure all valves operate correctly at shut-off system pressure conditions.
- Witness proper response from VFD (speed decreases as valves close).
- System operation stabilizes within 5 minutes after test procedures are initiated (no hunting).

Step 3: Adjust system operation to achieve 50% flow. Verify and document the following:

- VFD input power less than 30% of design.

Step 4: Adjust system operation to achieve a flow rate that would result in the VFD operating below minimum speed setpoint. Verify and document the following:

- Ensure VFD maintains minimum speed setpoint regardless of system flow operating point.

NJ.10.5 Variable Frequency Drive Controls

NJ.10.5.1 Construction Inspection

Prior to Acceptance Testing, verify and document the following:

- All valves, sensors, and equipment were installed per the design drawings.
- All installed valves, sensors, and equipment meet specifications.
- All sensors are calibrated.
- VFD minimum speed setpoint exceeds motor manufacturer's requirements.
- VFD minimum speed setpoint should not be set below the pumping energy curve inflection point (i.e. combination of pump-motor-VFD efficiency characteristics at reduced load may cause input power to increase upon further reduction in load).

NJ.10.5.2 Equipment Testing

Step 1: Open all control valves. Verify and document the following:

- System operation achieves design conditions +/- 5%.
- VFD operates at 100% speed at full flow conditions.

Step 2: Modulate control valves closed. Verify and document the following:

- Ensure all valves operate correctly at system operating pressure conditions.
- Witness proper response from VFD (speed decreases as valves close).
- System operation stabilizes within 5 minutes after test procedures are initiated (no hunting).

Step 3: Adjust system operation to achieve 50% flow. Verify and document the following:

- VFD input power less than 30% of design.

Step 4: Adjust system operation to achieve a flow rate that would result in the VFD operating below minimum speed setpoint. Verify and document the following:

- Ensure VFD maintains minimum speed setpoint regardless of system flow operating point.